# Comparative Techniques in Ventilation

## From Large to Small

Keith Simpson BVSc MRCVS
MIET(Electronics)

# Overview

- Look at the need for ventilation
- What else do you need when ventilating?
- Look at the different requirements for ventilation related to size
- Look at the effects of ventilation related to size

# Why Ventilate?

- The purpose of ventilation is 3-fold:

- Deliver adequate oxygen to the patient
- Remove $CO_2$ waste gas from the patient
- Deliver (or remove) anaesthetic agent to the patient

# When to ventilate?

- When the benefits outweigh the disadvantages !
- When there is any risk of compromise in respiratory function

# Causes of Respiratory Function compromise

- Anaesthetic Type: Respiratory depressant
- Animal physique/posture: Obesity
- Animal fitness: Toxic, shocked, lung disease
- Surgery: Intra-thoracic, muscle relaxants

# How do you know you have compromised respiratory function?

- Adequate monitoring
- Look at the animal: Resp. Rate, depth and nature of the breathing
- Look at the re-breathing bag – are tidal volume excursions consistent with animal size?
- Look at additional monitoring aids

# End-Tidal $CO_2$ Monitoring

- No single monitoring modality conveys as much information on respiratory function as Capnography.

- For any length of mechanical ventilation, where innate respiratory drive has been lost by the patient, then monitoring end-tidal $CO_2$ is mandatory

# Pulse-Oximetry

- Beware the pitfalls of Pulse-Oximetry
- Shows % saturation of blood NOT how much oxygen is available
- Normally used with 100% oxygen
- Real benefit of Pulse-Oximetry is in animals breathing air – 21% oxygen
or animals with severe lung pathology

# Mechanical Ventilation

- For the purpose of this talk this will relate to ventilators rather than manual ventilation (bag squeezing)

- The size range of animals that we encounter is vast – from mice to elephants
- Different sized animals have different ventilation problems

# Mechanical Ventilation

- We can broadly divide the animals we need to ventilate into 3 categories based roughly on tracheal size
- Small – ET tube size less than a 3.0
- Medium – ET tube size 3.0 to 18
- Large – ET tube size greater than 18

- Each category has unique requirements

# Mechanical Ventilation
# Medium (3.0 to 18.0mm ET size)

- This is our general “small animal” group size
- Typically 5kg – 100kg

- Not small enough for heat loss to be a big issue, but maintaining body temperature is helpful
- Not large enough for body mass to hinder normal respiratory movements, but obese or pregnant animals may be restricted

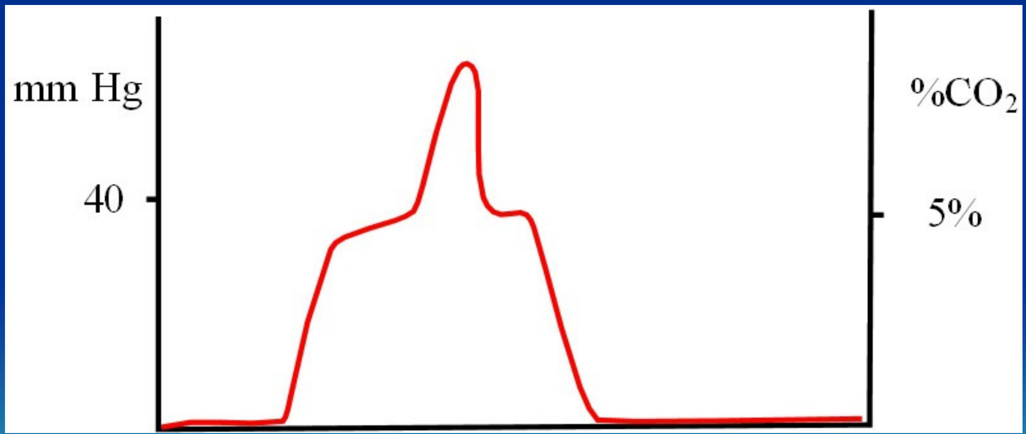
# Mechanical Ventilation Medium (3.0 to 18.0mm ET size)

- Still need to be aware of the effects of:

- Raised intra-thoracic pressure – keep I:E ratio at 1:2 or better
- Excessive ventilation pressures – either pressure cycle or use volume cycling with pressure limiting
- Single lung intubation – Capnograph will tell you this

# Single Lung intubation

- A large single spike superimposed on a normal phase is indicative of single lung intubation



# Mechanical Ventilation
# Small (Less than 3.0mm ET size)

- Light weight means posture during recumbency is less important

Main Problems

- Dead space must be minimised (<10% of tidal volume)
- Tubing resistance is significant
- Heat loss – Large SA:Mass ratio
- Monitoring can be more difficult

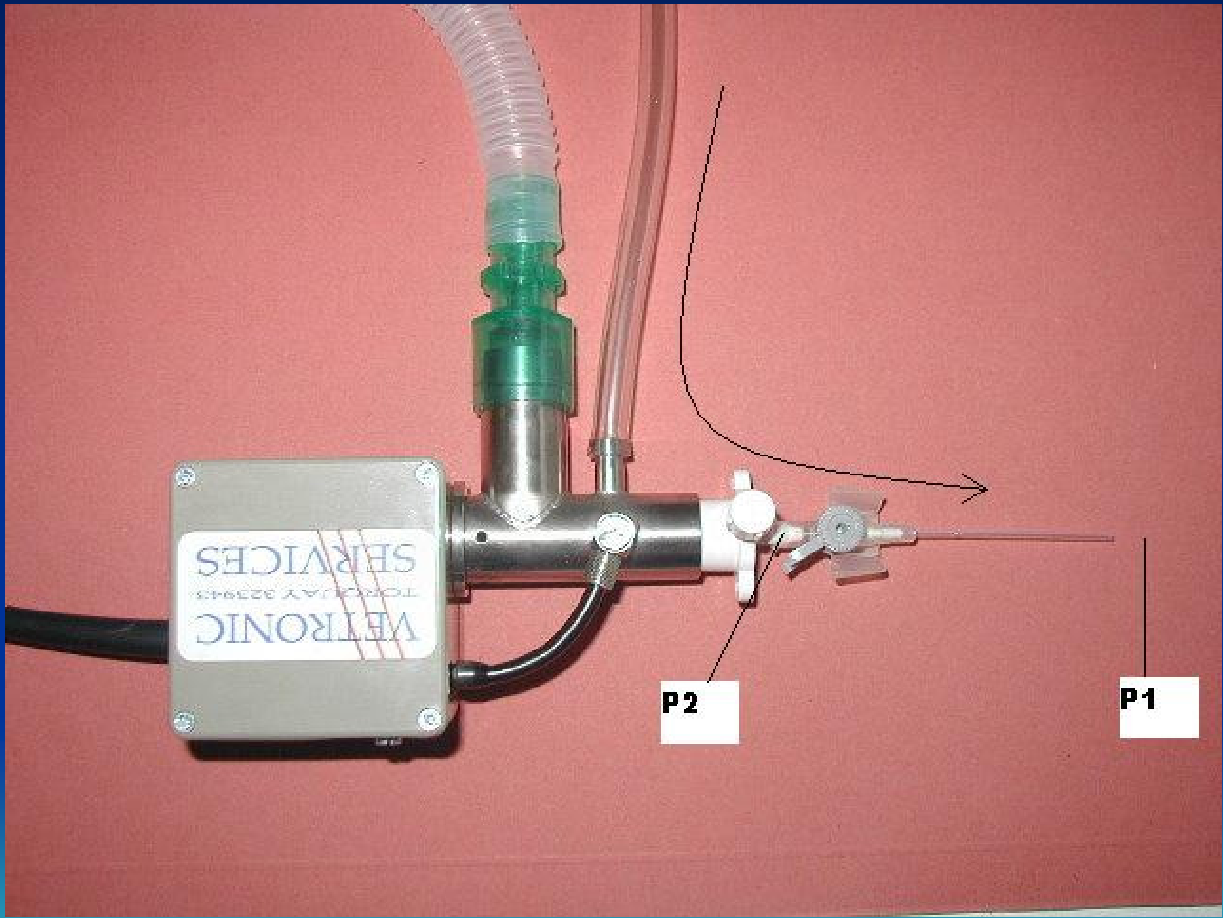
# Mechanical Ventilation
# Small (Less than 3.0mm ET size)

- Dead space
- May need to make up your own small connectors as commercially not available

# Example – 16G Catheter 50mm long, 1.4mm I/D

- This could be used for example for a rat intubation or for a small bird
- Rat: Wt 200g, Tidal volume 5mls
- Respiration rate: 60 per minute gives 0.3 seconds inspiration time with I:E ratio of 1:2 , 5mls in 0.3 seconds = 900mls per minute.

# Example – 16G Catheter 50mm long, 1.4mm I/D



# Mechanical Ventilation
# Small (Less than 3.0mm ET size)

## Tubing resistance

- Can have a huge impact on delivered volume
- Increasing the flow rate increases the pressure drop

16G 50mm Catheter

| Flow Rate (L/Minute) | Pressure drop (cm H2O) |
|---|---|
| 0.5 | 1 |
| 1.0 | 4 |
| 1.5 | 7 |
| 2.0 | 10 |
| 3.0 | 18 |

# Mechanical Ventilation
# Small (Less than 3.0mm ET size)

- Measure the pressure drop of the system you are about to use so that the compensation values can be determined Remember that the pressure drop is directly proportional to the ET tube length. Halve the tube length – halve the pressure drop
- Choose the shortest, widest bore ET tube that you can

# Mechanical Ventilation
# Large (Greater than 18mm ET size)

- Body mass now starts to have a significant impact on ventilation:
- Internal abdominal organs push forward on the diaphragm, reducing lung compliance
- Significant difference between dorsal lung perfusion and ventral lung perfusion – 50-60cm height differential. Perfusion best in lower lobes
- Significant difference between dorsal lung ventilation and ventral lung ventilation. Ventilation best in upper lobes

# Mechanical Ventilation
# Large (Greater than 18mm ET size)

- Inspiratory air flows start to become very large. E.g 400kg zebra, resp rate 10, with I:E ratio of 1:3 = 2 seconds inspiratory time.
- 4.0L delivered in 2 seconds = 120L/minute
- Minute volume = 40L
- Must use a rebreathing (circle) system
- Mechanical IPPV now required. Bag-squeezing cannot be maintained for long and tidal volumes and pressures cannot be monitored

# Mechanical Ventilation
# Large (Greater than 18mm ET size)

- Postural changes lead to reduced cardiac output and blood pressure. Increased intra-thoracic pressure can explain most of this effect
- IPPV will increase the mean intra-thoracic pressure and tend to worsen the cardiac output.
- Need to keep I:E ratio as large as possible. This means that to maintain the minute volume, the inspiratory time will need to decrease
- The large lung mass and long distances involved result in pressure drops. If inspiratory time is too short, may never reach driving pressure and alveoli are under-inflated.

# Mechanical Ventilation
# Large (Greater than 18mm ET size)

- Now have a situation where the animal has reduced cardiac output and reduced alveolar ventilation simply because of IPPV.
- Coupled with the inherent V/Q mismatches in the lung respiration can actually be much worse with IPPV
- Therefore be sure that your patient will benefit from IPPV

# Mechanical Ventilation
# Large (Greater than 18mm ET size)

- How can you minimise these negative effects?
- Posture – if possible, incline animal so abdominal contents are not pushing on diaphragm
- Use an inspiratory pause at the end of inspiration – allows time for gas to reach majority of alveoli. With no flow, there is no pressure drop so pressure will equalize and alveolar ventilation improves.
- Currently controversial, but: Use less than 100% oxygen. Rapid uptake of O2 leads to alveolar collapse and worsening gas exchange

# Mechanical Ventilation
# Large (Greater than 18mm ET size)

- Must monitor at least end-tidal CO2  and oxygen saturation levels. Preferably also blood pressure.
- This is a situation where pulse-oximetry can be very helpful, but only if your pulse-ox probe gives reliable readings.
- Tongue clips are generally not satisfactory. Use reflectance probes against nasal septum, held in place by cotton wool or swabs.

# Mechanical Ventilation
# Large (Greater than 18mm ET size)

- Nonin Reflectance probe

- For best use, place over an artery that has dense (preferably bone) tissue behind it

# Mechanical Ventilation
# Large (Greater than 18mm ET size)

## Indications for IPPV

- Apnoea
- Reduced oxygen saturation
- High end-tidal CO2 – what is high?
  - Species dependant and must remember that ET CO2 can be very different from PaCO2. use blood-gas analysis if available
- (Improved uptake of gaseous anaesthetic)

# That's all folks!