Selecting and Connecting Breathing Systems

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• Each booklet illustrates one way to perform a skill and it is acknowledged that there are often other approaches. Before using the booklets students should check with their university or college whether the approach illustrated is acceptable in their context or whether an alternative method should be used.
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Year Group: BVSc3 +
Equipment for this station:

- Pen
- Paper
- Calculator
- T-piece (in CSL a strip of white tape is around this system)
- Bain (in CSL a strip of orange tape is around this system)
- Lack (in CSL a strip of brown tape is around this system)
- Magill (in CSL a strip of black tape is around this system)
- Circle (in CSL a strip of green tape is around this system)
- Anaesthetic machine
- Endotracheal (ET) tube

Considerations for this station:

- Do not use the anaesthetic machine without supervision from a member of staff
- Towards the end of this booklet there is:
  - Information about factors that need to be considered when selecting breathing systems and the rationale
  - Scenarios to practise: to decide what is the most appropriate breathing system to select, the reasons for the choice and calculate the fresh gas flow rate in each case

Anyone working in the Clinical Skills Lab must read the ‘CSL_I01 Induction’ and agree to abide by the ‘CSL_I00 House Rules’ & ‘CSL_I02 Lab Area Rules’

Please inform a member of staff if equipment is damaged or about to run out.
Clinical Skills: Selecting and Connecting Breathing Systems

1. Connect the breathing system to the common gas outlet on the anaesthetic machine. There are labelled diagrams of commonly used breathing systems on the next two pages. The breathing systems in the demonstration boxes have been colour coded with a ring of tape to help with identification.

2. Connect the scavenging system to the breathing system (at the arrow).

3. Connect the breathing system to the patient, via an endotracheal (ET) tube (in the photo there is a capnography connector between the breathing system and the ET tube).

4. Check that the valve on the breathing system is open - as above.

5. INCORRECT: Valve is closed.

6. Follow instructions in ‘CSL_A04 Checking a Breathing System’ for guidance on how to check a breathing system.
**Breathing Systems**

Selecting and Connecting Breathing Systems

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**T-piece** (labelled with white tape)

- Connect to scavenging
- Connect to ET tube
  - NB The system also has a capnography connector
- Connect to gas flow (to common gas outlet)

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**Bain** (labelled with orange tape)

- Connect to scavenging
- Connect to ET tube
  - NB The system also has a capnography connector
- Bag on Expiratory limb of Bain
- Connect to gas flow (to common gas outlet)
Breathing Systems
Selecting and Connecting Breathing Systems

Magill (labelled with black tape)

- Connect to scavenging
- Connect to gas flow (to common gas outlet)

Parallel Lack (labelled with brown tape)

- Bag on Inspiratory limb of Lack
- Connect to scavenging
- Connect to ET tube
  NB The system also has a capnography connector
- Connect to gas flow (to common gas outlet)
Circle (labelled with green tape)

- Connect to ET tube
- Connect to scavenging
- Connect to gas flow (to common gas outlet)
- Soda lime canister (as the circle is a rebreathing system)

N.B. A soda lime canister must be used in conjunction with a rebreathing circuit, to absorb the CO$_2$ exhaled by the patient.

Over time the soda lime becomes saturated and must be replaced. This is done through a hole which is usually plugged but can be opened to allow access to the soda lime canister.
1. Disconnect breathing system from the anaesthetic machine, endotracheal (ET) tube and scavenging system.

2. Turn off the anaesthetic machine and scavenging if it has been in use (turned on).

3. Put all breathing systems back in the box.

Station ready for the next person:

Please inform a member of staff if equipment is damaged or about to run out.
I wish I’d known:
Selecting and Connecting Breathing Systems

- During an anaesthetic, ensure the breathing system doesn’t become kinked – this will obstruct gas flow to the patient.
- During an anaesthetic, ensure the breathing system doesn’t get twisted – this could twist the endotracheal tube which can damage the patient’s trachea.
- There are mini versions of some of the breathing systems so the weight ranges are for guidance only.
- There is a coaxial versions of the Lack and therefore being able to identify whether the bag is positioned on the inspiratory or expiratory limb.
There are a number of factors that influence the choice of anaesthetic breathing systems e.g.

- Size of the animal
- Is IPPV (Intermittent positive pressure ventilation) needed?
- Breathing system dead space

**IPPV (Intermittent positive pressure ventilation)**

- IPPV can be done manually or by a ventilator.
- IPPV may be needed when: Neuromuscular blocking agents are used, thoracotomy, diaphragmatic hernias, hypoventilation and raised ETCO$_2$ (on capnography).
- A T-piece, Bain or Circle can be used for prolonged IPPV. Any breathing system can be used to provide an occasional breath manually e.g. to manage post-induction apnoea.

**Breathing system dead space**

- This is the portion of the breathing system that does not participate in gas exchange. The amount of apparatus dead space is important, particularly in small animals as it can impact on the dead space to tidal volume ratio resulting in increase in PaCO$_2$ or increase the work required to breathe.
• **Rebreathing versus non–rebreathing systems**
  
  – **Rebreathing**: Expired CO₂ is removed by soda lime and the remaining gases (O₂ and anaesthetic agent) are mixed with fresh gas from the anaesthetic machine. The animal breathes the mixture of gases.
    
    
    • Disadvantages: Inspired inhalant anaesthetic agent often differs from the vaporiser setting and changes in percentage can be slow. Higher resistance than non-rebreathing system. Needs high fresh gas flow initially to remove air (denitrogenation).
    
    • Example: Circle
  
  – **Non-rebreathing**: Expired gases are removed from the breathing system by the fresh gas flow from the anaesthetic machine.
    
    • Inspired inhalant anaesthetic agent is the same as the vaporiser setting. Low resistance.
    
    • Disadvantages: Less economical and more atmospheric pollution. Loss of heat and moisture.
    
    • Example: Bain, Lack, T-piece, Magill

**Table Summarising Information About Breathing Systems**

<table>
<thead>
<tr>
<th>Breathing system</th>
<th>Multiple of minute volume*</th>
<th>Size of animal**</th>
<th>Suitable for IPPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>T-piece</td>
<td>2-3</td>
<td>&lt;10kg</td>
<td>Yes</td>
</tr>
<tr>
<td>Bain</td>
<td>2-3</td>
<td>&gt;8 to &lt;15-20kg</td>
<td>Yes</td>
</tr>
<tr>
<td>Lack</td>
<td>0.8-1</td>
<td>&gt;10 to &lt;25-30kg</td>
<td>No</td>
</tr>
<tr>
<td>Magill</td>
<td>1</td>
<td>&gt;5kg</td>
<td>No</td>
</tr>
<tr>
<td>Circle</td>
<td>NA</td>
<td>&gt;10kg</td>
<td>Yes</td>
</tr>
</tbody>
</table>

* Breathing system circuit factor  ** Approx. guidelines as some systems have miniature versions
• **Tidal Volume (Vt)**
  – Vt = the amount of air that enters the lungs during normal inhalation at rest (approximately 10mL/kg)

• **Minute Volume (Vm or \(\dot{V}\)m)**
  – Vm = total volume of gas inhaled or exhaled from the lungs in 1 minute
  – Vm = tidal volume \times\text{ respiratory rate}
  – Minute volume varies depending on species and usually decreases on a mL/kg/min basis as the size of the animal increases
  – 200mL/kg/min – a reasonable approximation to use for small animals

• **Calculating Fresh Gas Flow (FGF)**
  – The amount of gas flow to use with a particular breathing system needs to be adequate to flush expired CO\(_2\) through the system so that inspired gases do not contain CO\(_2\)
  – Use the estimate for minute volume (see above) then follow the equation:
    • FGF = Vm \times\text{ breathing system factor}
  – In rebreathing systems initially a high flow is used for denitrogenation (removing nitrogen in the lungs and breathing system). Afterwards the rate can be set to 10mL/kg/min (as a MINIMUM) although a minimum flow of 1L/min O\(_2\) is usually used. Any extra above the oxygen requirement is lost to the scavenging system.

• By using these calculations the fresh gas flow (FGF) needed for the animal can be estimated. This may need to be altered under certain circumstances, for example if the respiratory rate changes.
• **Fresh gas flow (FGF) for different breathing systems**

• **Circle**
  - Theoretically the minimum O\(_2\) flow required for a circle is equal to the animal’s metabolic O\(_2\) requirements. This may be estimated as:
    - Small animals - 10mL/kg/min
      - In practice for small animals use a minimum of 1L/min
    - Large animals - 5mL/kg/min
      - If rapid changes in anaesthetic depth are required the O\(_2\) flow should be turned up at the same time as the vaporiser is adjusted.

• **Bain**
  - FGF = minute volume x 2 to 3 (= 3.6 to 7.2L/min)
    
    \[
    \text{minute vol} = 200\text{mL/kg/min} \\
    = 9.2 \times 200 \\
    = 1840\text{mL}
    \]

• **Lack**
  - FGF = minute volume x 1
    
    = 1.8L/min

• **Magill**
  - FGF = minute volume x 1
    
    = 1.8L/min

• **Circle**
  - FGF = metabolic O\(_2\) requirement = 10mL/kg/min
    
    = 10 \times 9.2 = 92mL/min*

  * In practice use a minimum of 1L/min with a circle
Select the most appropriate breathing system for the following scenarios and list the reasons for your choice. There may be more than one correct answer. Also work out the fresh gas flow (FGF).

1. A 9 month old female cat has been brought to the surgery to be neutered. She weighs 3.2kg. What breathing system(s) would be the most appropriate for this case?

2. A 55kg Newfoundland has a dental booked at the practice. What breathing system(s) would be most appropriate for this case?

3. You are on clinical rotations and a 15kg Springer Spaniel is set to have a thoracotomy. What breathing system(s) would be most appropriate for this case?

4. A 9.2kg Whippet is coming in for a digit amputation. What breathing system(s) would be the most appropriate for this case?
1. A 9 month old female cat has been brought to the surgery to be neutered. She weighs 3.2kg. What breathing system(s) would be the most appropriate for this case?

**T Piece**
- Low resistance as is small patient.
- FGF = minute volume x 2 to 3
  
  \[
  \text{minute volume} = 200 \text{mL/kg/min}
  \]
  
  \[
  = 200 \times 3.2
  \]
  
  \[
  = 640 \text{mL/min}
  \]
  
  \[
  \text{FGF} = 640 \times 2 \text{ to } 3 = 1.28 \text{ to } 1.92 \text{L/min}
  \]

**Mini-Lack**
- FGF = 1 x minute volume
  
  \[
  = 640 \text{mL/min}
  \]
  
  N.B. 640mL may be difficult to set on the flowmeter so set the FGF to **1L/min**

2. A 55kg Newfoundland has a dental booked at the practice. What breathing system(s) would be the most appropriate for this case?

**Circle**
- Rebreathing system, allows lower fresh gas flow so is more economical
- Metabolic O₂ consumption estimate = 10mL/kg/min
- FGF = 10 x 55kg = **550mL/min**
- A minimum FGF to **1L/min** is usually used for a circle in practice
3. You are on clinical rotations and a 15kg Springer Spaniel is set to have a thoracotomy. What breathing system(s) would be the most appropriate for this case?
   
   – Will need IPPV as thorax will be open

   **Bain**
   
   – Can use for patients 10-20kg.
   – Minute volume = 200mL/kg/min
     
     = 200 x 15
     
     = 3L/min
   
   – FGF = minute volume x 2 to 3
     
     = 3L x 2 to 3
     
     = 6 to 9L/min

   **Circle**
   
   – Rebreathing system, allows lower fresh gas flow so is more economical
   – Metabolic O₂ consumption estimate = 10mL/kg/min
   – FGF = 10 x 15kg = **150mL/min**
   – N.B. Usually a circle FGF is set to a minimum of **1L/min**

4. A 9.2kg Whippet is coming in for a digit amputation. What breathing system(s) would be the most appropriate for this case?
   
   – Bain, Circle, Lack or Magill
   – Whippets tend to have a large lung capacity in comparison to body weight and so would be able to cope with resistance of a breathing system when other dogs of the same weight might not.