# Managing the respiratory effects of snake envenomation

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## General principles of respiratory management

In general the aim of respiratory management is to maintain adequate gas exchange. That is, absorption of oxygen and removal of carbon dioxide.

This requires:

- A patent (and protected) airway.
- Ventilation (moving air).
- Functioning alveoli.
- Perfusion of (blood flow to) alveoli.

In the envenomed patient, the respiratory problems are airway and/or ventilation problems:

- Progressive deterioration in conscious state leading to upper airway obstruction.
- Progressive deterioration of muscle strength leading to hypoventilation.
- Pulmonary aspiration of saliva or vomitus (due to not protecting their airway).

In snake envenomed patient, the aim of respiratory management is to maintain adequate ventilation and to prevent respiratory complications until definitive treatment for the underlying problem can occur, and their muscle power has returned to near normal.

In managing these patients, it is important to **do the basics well**.

In this chapter we will cover:

- Non-invasive airway management.
- Manual ventilation.
- Invasive airway management.
- Mechanical ventilation.

# Non-invasive airway management

We first need to assess the patient's airway. Are they maintaining their airway? Are they protecting their airway?

It is important to continually reassess the airway, as the natural history is for progressive deterioration. We need to ensure that the airway is both patent and protected.

**Is the airway patent?**

- Rise and fall of the chest.
- Feel for air movement.
- 'Misting' in the oxygen mask.
- A 'rocking boat' pattern (alternate elevation of the chest then the abdominal wall) means attempted ventilation against an upper airway obstruction.
- Lack of air movement may be due to airway obstruction, or hypoventilation.

**Airway patency can be maintained using**

- Body Posture:
  - Left or right lateral.
- Simple airway manoeuvres:
  - Jaw thrust.
  - Chin lift.
- Simple upper airway devices, eg. Guedel airway, nasopharyngeal airway.

**Is the airway protected?**

- Absent gag reflex – airway not protected.
- GCS <9 – airway not protected.

If the patient is not protecting their airway, endotracheal intubation should be performed. If this is not possible, or not available, then the patient should be nursed in the left lateral position with suction available. They require 1:1 nursing and should be suctioned immediately if there are any secretions/vomit in the oropharynx. The obstructed airway that is being managed in a non invasive manner is NOT secure and needs continual monitoring and reassessment.

## Manual ventilation

1. **Expired air resuscitation "mouth to mouth".**
   - $FiO_2$ ~ 16%.
   - Technically difficult.
   - Tiring, especially if single operator.

2. **Bag/Valve/Mask.**
   - Can use room air ($FiO_2$ ~ 21%) or supplemental $O_2$.
   - For envenomed patients with normal lungs, supplemental $O_2$ is less likely to be necessary. Adequate ventilation is **VERY** important.
   - If using supplemental $O_2$, the reservoir bag is important.

- Considerations:
  - o Bag
    - ~ Rate (breaths/minute) x tidal volume (volume of each breath) = minute ventilation (minute volume).
    - ~ Rate 12/min. x volume ~500ml = 5-6 litres/min. (average adult).
    - ~ Rate 15–25/min. x 8 ml/kg tidal volume (child or infant).
    - ~ Bag volume varies with brand and size (neonatal, paediatric, adult).
  - o Mask
    - ~ Size
    - ~ Seal
    - ~ Airway maintenance
      - ö Use upper airway devices – Guedel/oropharyngeal.
      - ö Simple airway manoeuvres – jaw thrust, chin lift.

Bag valve mask ventilation is a skill that requires hands-on practice.

A very important part of the skill is continuously monitoring the effectiveness of the ventilation and appropriately modifying the technique. If the way that you are trying to bag/valve/mask ventilate the patient is not working, then you need to change something; for example, mask size, hand grip, jaw manoeuvre, or by adding an airway device.

# Invasive airway management

This section of the chapter covers techniques where equipment is placed into the laryngopharynx and lower in the airway. It is not intended as a comprehensive course in how to intubate, but as a discussion of how to use various airway management techniques with envenomed patients. The practical skills component will be covered in the practical session.

## 1. Endotracheal intubation

- Advantages:
  - o Both maintains and protects the airway (with the cuff in the trachea).
  - o Relatively secure.
  - o Allows for mechanical ventilation.
- Disadvantages:
  - o Technical skill and equipment is required and is not always available.
  - o In some cases it may be technically very difficult.
  - o Patient must be adequately sedated to tolerate the tube.
  - o The procedure is associated with some complications.
- Indications:
  - o Patient is not protecting their airway.
  - o Marked pooling of secretions.
  - o $PaO_2$<60mmHg or $PaCO_2$>60mmHg despite best available non-invasive respiratory support.
  - o Cyanosis.
  - o Apnoea (the patient is not breathing).

Envenomed patients will require intubation if they become too drowsy (due to hypoxia, intracranial bleeding, or the use of sedative agents) to adequately maintain and protect their airway, or if they develop respiratory muscle paralysis to the extent that they are unable to make sufficient respiratory effort. They will not be adequately fasted, and may be nauseated and vomiting, and so will require a rapid sequence intubation to reduce the risk of pulmonary aspiration. The respiratory state of envenomed patients will, generally, deteriorate gradually. Once it becomes apparent that the patient is going to require intubation (**before** they deteriorate to the point that they need immediate intubation), the patient can be intubated 'semi-electively'. Equipment is prepared and checked and personnel assembled so that the intubation occurs in a planned, orderly and controlled manner.

**Rapid sequence intubation**

- Everything checked, worked and at hand.
- Pre-calculated drug doses.
- Fast-acting muscle relaxant (suxamethonium).
- Pre-oxygenation.
- Introducer pre-loaded (if available).
- Suction at hand.
- Cricoid pressure.
- **ALWAYS** check and confirm ETT tube position.
- Secure tube.

## 2. Laryngeal mask airways (and combitubes)

These are devices that sit in the oropharynx and provide a maintained and relatively secure airway but do not protect the airway in the same way as an ETT, especially if using positive pressure ventilation.

They work by delivering air into the laryngopharynx, which they hold open. They require relatively normal anatomy to work effectively. Depending on their design, they may have a 'cuff' in the oesophagus to discourage aspiration but as the oesophagus is an easily distensible tube this will not always be effective. None of these devices have a cuff in the trachea.

Since none of them protect against aspiration (especially for a patient who is being positive-pressure ventilated), when it comes to the management of envenomed patients, they are a "second best" alternative to an endotracheal tube.

They may have a limited role where endotracheal intubation is not possible and the patient's airway is not able to be maintained by other means; but, it must be remembered that these patients are still at risk of aspiration, which may be hidden by the airway device, and they need to be closely monitored for this.

## 3. Mechanical ventilation

The aim of ventilation in envenomed patients is to provide adequate gas exchange until the envenomation can be definitively treated and the patient has recovered. Unless they have co-morbidities (eg. COAD), or have already sustained complications (aspiration), envenomed patients should have normal lungs and be easy to ventilate, since their problem is with their weak respiratory and bulbar muscles.

**Types of ventilators/modes of ventilation.**

There are many different brands and models of ventilators and the different terminology they use can become confusing when really they are all doing the same job. There are only a limited number of parameters that can be manipulated.

All ventilators provide Positive Pressure Ventilation (PPV). They do this by either pushing a set volume of air into the patient over a set time (volume-driven ventilators) or by applying a set positive pressure to the patient for a set time (pressure-driven ventilators). Some transport ventilators (eg. Oxylog 2000) only operate as volume-driven ventilators, while others can run in volume- or in pressure-driven modes.

With a volume-driven ventilator, the pressures achieved will depend on the patient’s lung compliance as well as the volumes and times set. In this situation airway pressures (peak and mean) should be measured to see that they are not too high.

With a pressure-driven ventilator, the tidal and minute volumes will depend on the patient’s lung compliance as well as on the pressures and times set. In this situation, the tidal and minute volumes should be measured to see that they are appropriate for the situation.

Whether using a pressure- or a volume-driven ventilation mode, the aim should be to ventilate the patient with the lowest pressures that achieve adequate tidal volume (and minute ventilation).

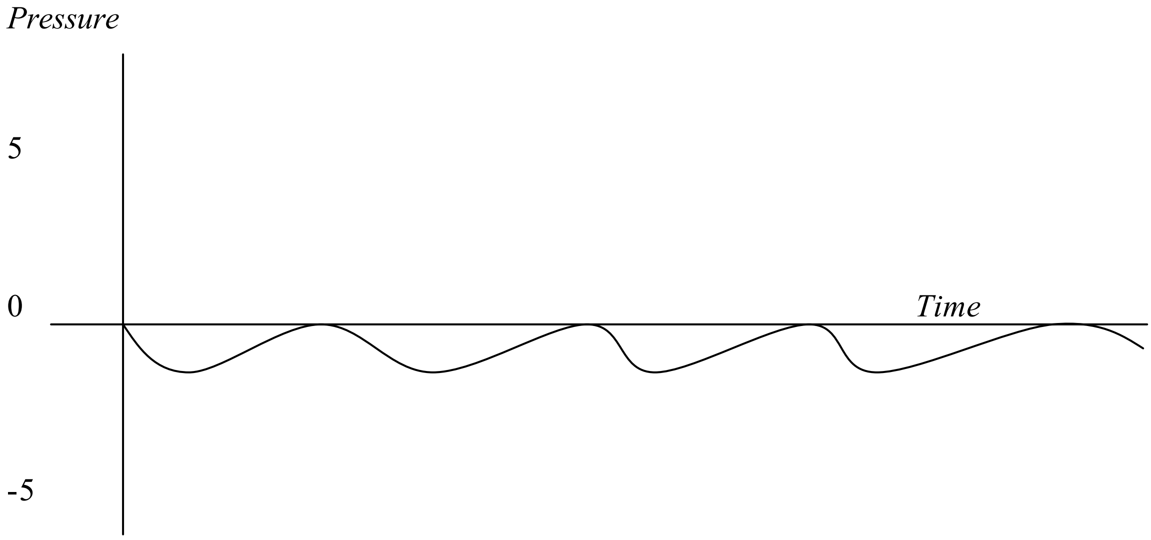
The breath rate (breaths per minute) must be set. Whether the ‘breaths’ are delivered in a volume- or a pressure-driven fashion, they can be either ‘mandatory’ or ‘triggered’. Mandatory breaths are delivered at a set frequency, regardless of the patient’s respiratory effort. This mode is useful if the patient is not making any respiratory effort. Triggered breaths are triggered by the patient’s respiratory effort. This mode is good for keeping the ventilator ‘co-ordinated’ with the patient, and it is very important that the sensitivity of the trigger is appropriate to the amount of respiratory effort the patient is making. Some ventilators allow a combination of ‘triggered’ and ‘mandatory’ breaths to be used.

The amount of time that is spent in inspiration and expiration can also be set, and this is often expressed as the inspired: expired (I:E) ratio.

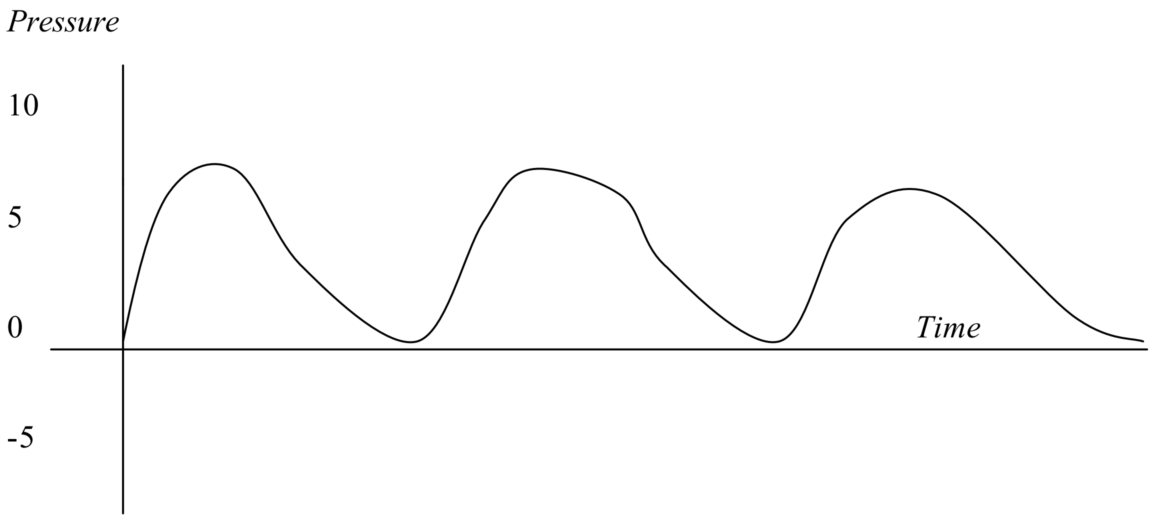
In addition to the number and way that breaths are delivered, it is important to consider the ‘resting’ pressure in the circuit between breaths, the end expiratory pressure. This pressure can be kept above atmospheric pressure either by the ventilator itself, or by using an expiratory valve in the circuit. This pressure is called PEEP (positive end expiratory pressure). Increasing the PEEP increases the end expiratory volume of the lung, which may make more alveoli available for gas exchange, by keeping them inflated.

The following diagrams show pressure changes in the lung with normal breathing, positive pressure ventilation and the addition of PEEP.

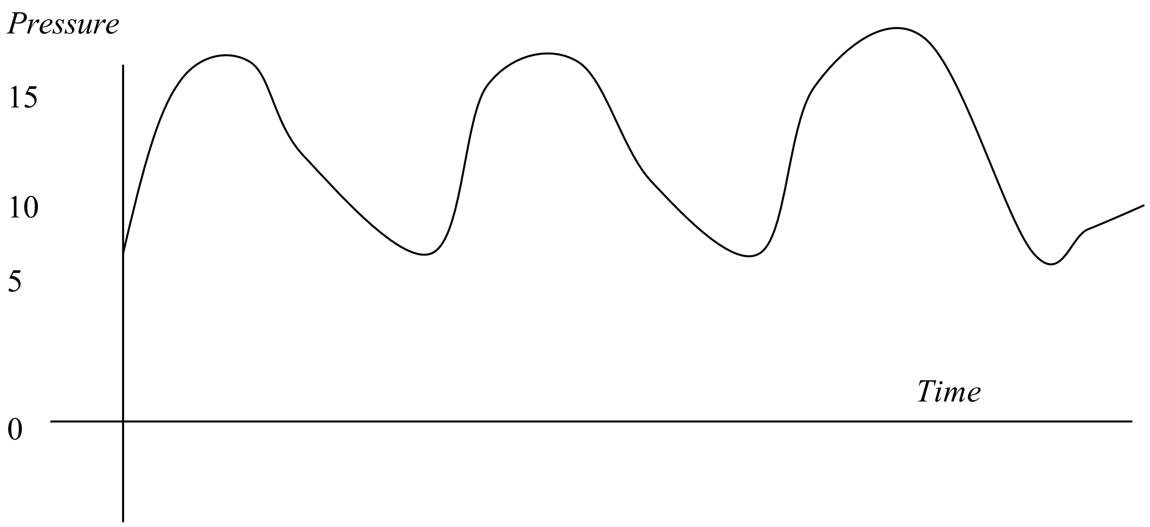
Normal Breathing




***Positive Pressure Ventilation***




***PEEP (5cm H2O)***



Initially the ventilation settings need to be chosen based on the patient's size and clinical problem. For this discussion it will be assumed that envenomed patients have normal lungs. A tidal volume (70-80ml/kg) and a rate (12/minute) are chosen, and the minute ventilation (volume) determined. The I:E ratio should be 1:2. Start with an $FiO_2$ of 100% until the patient's requirements are established. Some envenomed patients may have co-morbidities that will require more specialised ventilation techniques (eg. COAD).

Then, look at the effect of the ventilator settings chosen for the patient and make appropriate adjustments, as necessary:

- Check that the pressures (mean and peak) are not too high.
- Check a blood gas.
  - Is the $PaO_2$ adequate (should the $FiO_2$ be reduced or increased)?
  - Is the $PaCO_2$ acceptable (should the minute ventilation be increased or decreased)?

Close monitoring and continual, appropriate adjustment of ventilator settings is at least as important as the initial settings.

During mechanical ventilation, it is important that the patient is kept comfortable with adequate analgesia and sedation, and is paralysed if indicated. It is also important to ensure that all tubing is very **secure** and that a disconnection alarm is used.

Unless envenomed patients are treated **early** with appropriate antivenom, they are likely to require ventilation for several days (median 13 hours for a death adder envenomation, 88 hours for a taipan envenomation; Lalloo *et al*, 1995).

Consideration of the problems associated with long-term ventilation of patients needs to start from day one. This includes consideration of pressure care, eye care, fluids and electrolytes, and nutritional needs.

As the envenomed patient begins to recover, they will gradually be able to take on more of the respiratory work from the ventilator. The exact weaning method will vary according to the ventilator modes available.

It is **very** important to ensure that the patient is not extubated, or is allowed to extubate themselves (many deaths in hospital have occurred this way; McGain *et al,* 2004) until they are able to protect and maintain their airway and exhibit sufficient respiratory effort.

# References

LALLOO DG, TREVETT AJ, KORINIHONA A, *et al*. (1995a) Snake bites by the Papuan taipan (*Oxyuranus scutellatus canni*): Paralysis, hemostatic and electrocardiographic abnormalities, and effects of antivenom *Am J Trop Med & Hyg.* 52(6): 525-31.

MCGAIN F, LIMBO A, WILLIAMS DJ, DIDEI G, WINKEL KD. (2004) Severe Snakebite at Port Moresby General Hospital, Papua New Guinea 1992-2001. *Med J Aust*. (In press.)