Mechanical Ventilation of the Newborn

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Introduction

Caring for an infant requiring assisted ventilation is one of the greatest challenges that NICU staff face. We need to understand normal lung physiology in addition to the pathophysiology of various pulmonary diseases or problems. New techniques of ventilation are developing all the time, and the choices for appropriately ventilating infants are now greater than ever before.

Aim

The aim of this package is to discuss ventilatory support/ modes and methods used in the Neonatal Intensive Care Unit (NICU) at John Hunter Children's Hospital (JHCH).

Learning Outcomes or Learning Objectives

By completion of this program the learner should be able to:

- Discuss the various types of ventilation available in the NICU
- Describe the common parameters used in ventilating
- Explain the use of Nitric Oxide
- Safely troubleshoot complications associated with mechanical ventilation
- Assemble the patient circuit of a Stephanie ventilator

Pre-requisites

Prior to undertaking this learning package, it is assumed the reader will have a basic understanding of neonatal respiratory physiology and pulmonary mechanics.

Learning Package Outline

The package is designed to be a self-directed learning experience that will guide you through the literature and clinical issues related to mechanical ventilation of the newborn infant.

This package is developed within an adult learning framework so not all activities need to be documented but it is expected that you will complete them in order to facilitate your learning.

On completion and submission of this learning package a record of your completion will be added to your professional development record in MYLINK and you will be credited with PD hours. PD hours are accredited before the package is issued and carries a non variable amount of points. This allocation will be decided by the person completing the SDLP and a qualified distributer of points.

Problem based learning

This program is based on a problem-based approach to learning. This approach has been chosen to enhance critical thinking, and to create a body of knowledge that staff can apply to practice. Problem based learning (PBL) is characterised by the use of patient specific problems or situations as a context for developing problem-solving skills and for acquiring clinical knowledge.

How to use this resource or Instructions for participants

Some possible items might include:

- A comment about how many hours per week or how long is an expected time to complete the package this can be reasonable and flexible i.e. discuss with person giving you the package.
- Completion of this package is equivalent to Continuing Professional Development (CPD) points which is a requirement for National

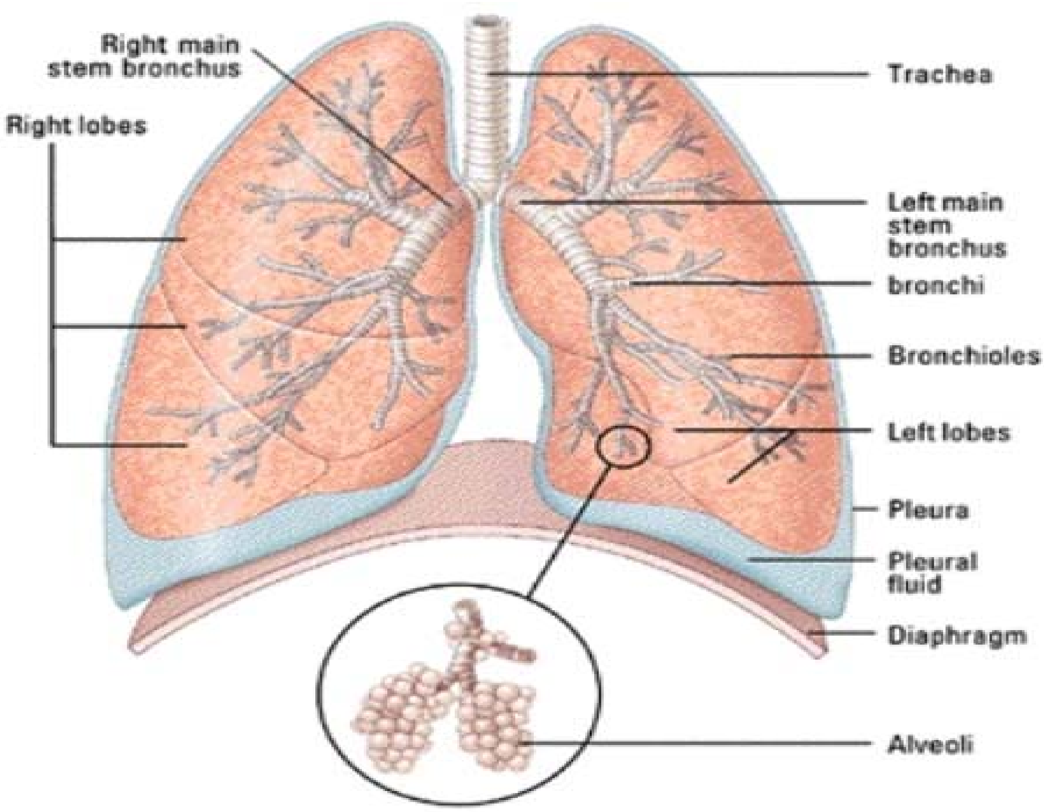
Registration. A certificate identifying CPD points will be given on the successful completion of the package.

- This package can be used as an introduction for nurses wishing to further their knowledge and skills in this area.
- At the completion of this learning package you are asked to complete questions or a problem based scenario related to the topic.
- There is a suggested reference list and it is by no means complete. Please read widely to facilitate your learning.
- This resource has been written from a Hunter New England Area Health perspective so it is not specific to any one health facility. Throughout the package procedures from the John Hunter Children's Hospital have been mentioned as an example of practice only.
- When complete you can return the package to relevant nurse educator/ CNE / CNC who will discuss it with you.

Recommended Readings

Any essential or suggested readings or resources can be identified in this section. Include any internet links and or web pages for reference in this section.

1. Verklan.M.T.,& Walden.M., (2010) Core Curriculum For Neonatal Intensive Care Nursing. 3rd Ed. Elsevier (USA)



Terminology of Mechanical ventilation

Compliance

Compliance is the elasticity or distensibility of the lungs and chest wall and is calculated from the change in volume per unit change in pressure[1].

$$\text{Compliance} = \frac{\triangle \text{Volume}}{\triangle \text{Pressure}}$$

Resistance

Resistance is the capacity of the gas –conducting system (airways, endotracheal tube and lung tissue) to oppose airflow[1].

Tidal Volume

This is measured in mls, the volume of gas moved with each breath.
Is approximately 4-8ml/kg

Minute Volume

Tidal volume multiplied by the rate in one minute

Modes of ventilation

Ventilatory mode usually refers to the way a ventilator supports respiratory effort. This may include modes where only spontaneous breathing efforts take place or where only mechanical breaths are given or a combination of these.

Controlled mechanical ventilation
In controlled mechanical ventilation (CMV) or intermittent mandatory ventilation (IMV) all breaths are initiated and delivered via the mechanical ventilator – eg used for infants with little respiratory drive or muscle-relaxed infants.

Triggered modes
Are those in which the patient plays a significant role in the initiation of a breath and include assist control (AC) ventilation, and synchronised IMV (SIMV).

Continuous positive airway pressure (CPAP)
A third type of support may be delivered through infant ventilators, although technically this is not a ventilator mode at all because no mechanical breaths are given. It is referred to as continuous positive airway pressure (CPAP). With CPAP the infant breathes spontaneously through the ventilator circuit and exhales against a mechanical device designed to maintain the airway pressure above atmospheric pressure throughout the respiratory cycle. CPAP delivered via an ETT has a high level of airway resistance.
CPAP may also be supplied with systems that do not incorporate mechanical ventilators such as the Columbia method of respiratory support used in NICU JHCH.

Peak Inspiratory Pressure (PIP)

PIP is the highest pressure delivered at the end of inspiration during a mechanical breath. Pressure limiting refers to a technique in which the highest pressure that can be met during the inspiratory cycle is preset. If this level is met before the inspiratory time has ended, inspiration will continue with pressure held at the preset level. This creates, in effect, a pressure hold or pressure plateau. The term "pressure limit" generally refers to a pressure hold mechanism, and the terms *pressure pop off and pressure relief* refer to an aborting mechanism.

The time required for pressure to reach the preset PIP depends on a number of factors, including the characteristics of the patient's lungs and airways (compliance and resistance), the flow rate of gas set on the ventilator, and, in some cases, the waveform adjustment on the ventilator. Once the PIP has been met, the flow will decrease as needed to maintain the pressure at the preset level for the remainder of the preset inspiratory time.

For neonatal ventilators, the peak pressure is limited to a clinician determined ‘safe’ level dependent on the neonate’s gestation, postnatal age and disease state to deliver adequate tidal volumes for appropriate gas exchange. An initial PIP setting of 20 to 25 cm H20 has been suggested as an acceptable starting point in infants with hyaline membrane disease. If a ventilator has a pressure pop off this should be set for a value slightly higher than the PIP. Ventilators used today usually have pop off valves and/or high pressure alarms.

Positive end expiratory pressure (PEEP)

PEEP is a mechanical technique that prevents the pressure in the patient's lungs from returning to atmospheric levels (conventionally referred to as "O") at the end of expiration. This technique is widely used in both infants and adults as a mechanism for avoiding alveolar collapse at the end of each breath, avoiding the need to use high pressures or high patient effort to re-- expand alveoli with the next breath.

Mean airway pressure (MAP)

Mean airway pressure is not a ventilator setting but rather the average pressure generated in the lungs over time. It is determined by several factors, including the pressure waveform (flow rate), inspiratory time, expiratory time (which is influenced by rate settings), peak pressure, and PEEP. Manipulations of any of these settings may be useful in adjusting the mean airway pressure. Infant ventilators have the ability to continuously monitor and display mean airway pressure, allowing the clinician to see the effects of ventilator adjustments on this value. If oxygenation is adequate at a given mean airway pressure, altering ventilator settings (eg. prolonging inspiration and reducing peak pressure) without changing the mean airway pressure should maintain this oxygenation level. Thus monitoring of this parameter can be helpful in maintaining gas exchange while avoiding some of the harmful effects of mechanical ventilation.

I:E Ratio

I:E ratio refers to the relationship between inspiratory time ("I") and expiratory time ("E"). Conventionally, inspiratory time is expressed as "I" in this relationship; for instance, if inspiratory time is 1 second and expiratory time is 2 seconds, the I:E ratio is expressed as 1:2. If the times are reversed, however, such that inspiratory time is 2 seconds and expiratory time is 1 second, the I:E ratio is expressed as 1:0.5 (not 2: 1). The I:E ratio at "normal" breathing rates is usually considered to be about 1:2. In infant ventilation, ratios in which inspiratory time is prolonged in comparison to expiratory time are referred to as reversed ratios, but these are rarely used..

Demand and continuous flow

Most infant ventilators incorporate IMV and CPAP modes of ventilation, meaning that they must have some system for supplying gas for spontaneous breathing, either for all breaths (CPAP) or for some (IMV). Most infant ventilators use a continuous flow system in which gas flows constantly through the breathing circuit. The patient can inhale from this gas flow at any time. The flow is also used to supply gas for mechanical breaths in IMV or control modes. Some ventilators incorporate a demand flow system instead of a continuous flow. In a demand flow system, the machine must sense when the patient wants a spontaneous breath and supply flow at that time.

Flow rate

The ventilator flow rate is a major determinant of tidal volume delivery and, in many ventilators, also serves as the source of gas for spontaneous breaths in the IMV and CPAP modes. A "cushion" of flow is usually provided to allow for sudden changes in infant ventilation. When using pressure-limited ventilation, the flow rate is adjusted so that the desired value of peak inspiratory pressure can be achieved. In pressure-limited ventilation, increasing the flow rate will result in meeting the pressure limit sooner and increasing the length of the inspiratory pressure plateau; and resultant increase in mean airway pressure. High flow rates may however decrease airflow to the periphery due to the increased likelihood of turbulent flow patterns.

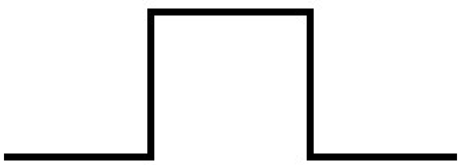
Sine waveforms

(also known as sinusoidal waveforms) are where the inspiratory pressure gradually builds to a peak just before expiration. There should be less barotrauma to the airways than with a square wave.

Sinusoidal

Square waveforms

are where the PIP is reached rapidly and then held for longer periods than with a sine waveform. This may be advantageous with atelectatic areas of the lung, but can also contribute to barotrauma.



Square

Servo-control

The term "servo-controlled" simply means that the function of some device is controlled by feedback from sensors. The simplest example is a servo-controlled humidifier, which incorporates an external temperature probe that senses gas temperature, usually close to the patient airway connection. The probe feeds back information to the humidifier heater, which turns off and on as needed to maintain a set temperature at the patient interface. Servo-control may also be used within a ventilator to control valves, volume delivery, airway pressure, or other parameters.

Trigger

The trigger is responsible for initiating breaths after detecting respiratory effort from the patient. Respiratory effort is detected via the pneumotachograph sensor that distinguishes changes in airflow and pressure.

Sensitivity
Sensitivity refers to the ease with which a ventilator can sense the patient's demand for a breath in airway-triggered devices. It is usually expressed as the amount of negative pressure or flow a patient must create in order for the ventilator to respond.

Humidification
Ideally, the humidification system used should have a system for maintaining a constant gas temperature and a constant water level to maintain the compressible volume and the volume of gas delivered. Both under humidification and over humidification can cause problems. Cool gas applied to the airway may result in significant heat loss through the respiratory tract, as well as drying of respiratory tract secretions, with the usual consequence of an occluded endotracheal tube. Over humidification may result in significant systemic fluid gain with circulatory overload in the infant.

Aims of Neonatal Mechanical Ventilation

The general indications for mechanical ventilation include the presence of complete apnoea, or periods of apnoea resulting in significant clinical deterioration that do not respond to other measures; acute hypercapnia (ventilatory failure); and acute hypoxemia not responsive to simpler therapeutic interventions. Other criteria that have been suggested for ventilation include symptoms of shock in any infant, regardless of perceived adequacy of gas exchange, and the presence of asphyxia or distress in any infant of less than 1000g birth weight.

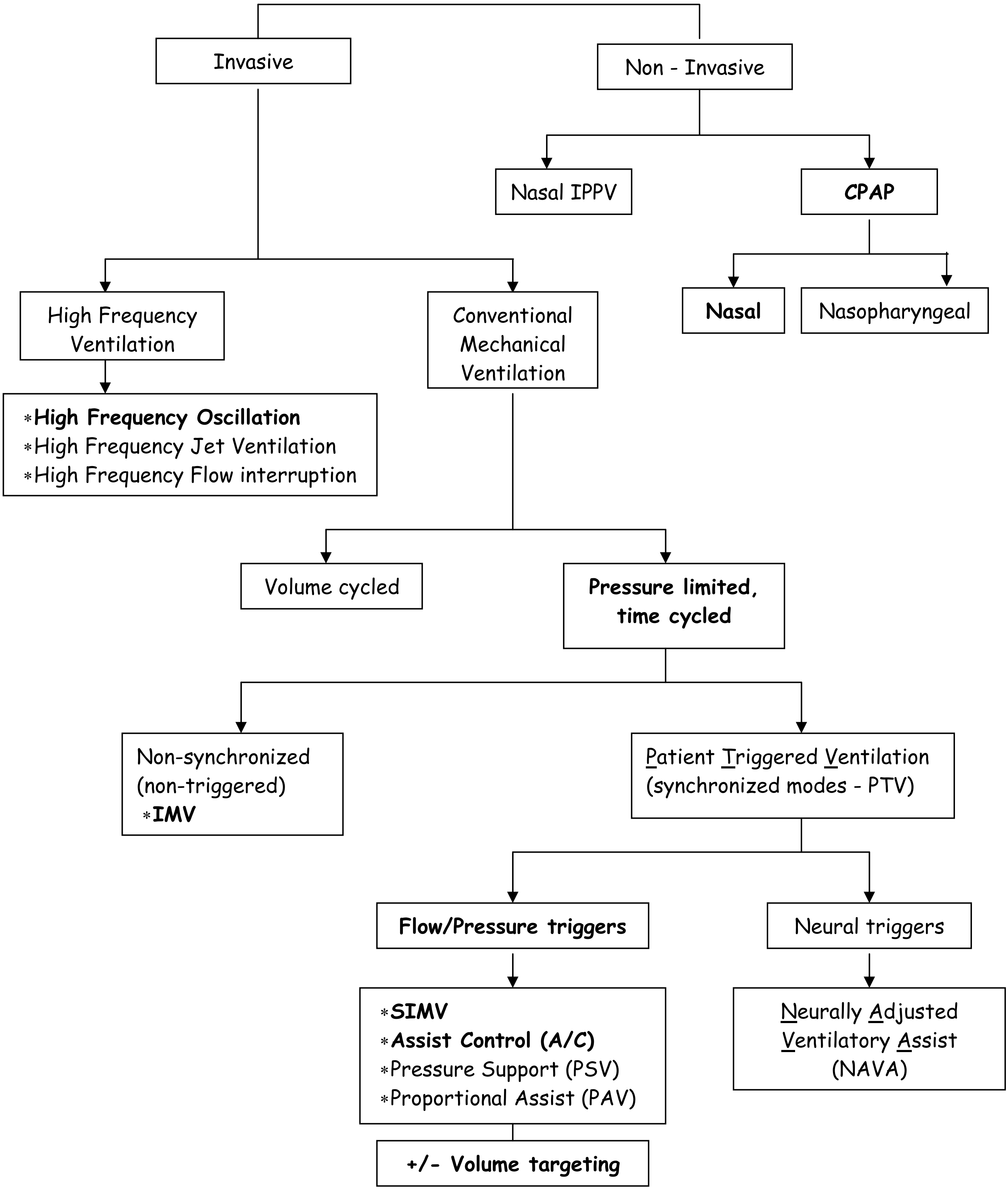
The general aims of neonatal ventilation include:

- Sustain life - reduce mortality
- Take over/ reduce the work of breathing
- Facilitate gas exchange
    - Achieve normal arterial oxygenation
    - Achieve normal carbon dioxide removal
- Re-expand atelectatic (collapsed) alveoli
- Minimize risk of lung injury

Considerable controversy exists over the "best way" to ventilate newborns, and there is little evidence that one method is significantly superior to another in reducing chronic lung disease. However, ventilator – patient asynchrony does result in reduced tidal volumes and increased work of breathing with increased oxygen consumption. This has clinical consequences of patient restlessness, increased sedation needs, increased risk of air-leaks and intraventricular haemorrhage. Consequently there has been much interest in improving ventilator-patient synchrony by using triggered modes of ventilation.

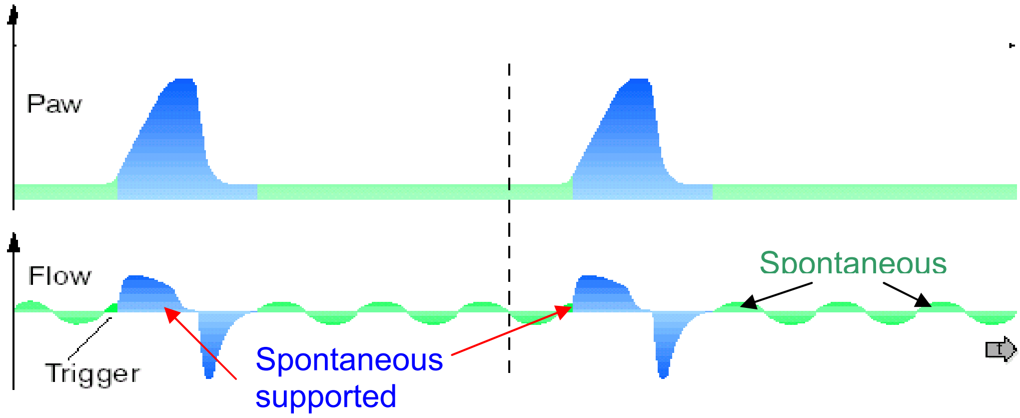
The various modes of mechanical ventilation used in the neonate are described in the following flow-chart with the common modes used in the NICU at JHCH highlighted in bold font.

Modes of Mechanical Ventilation



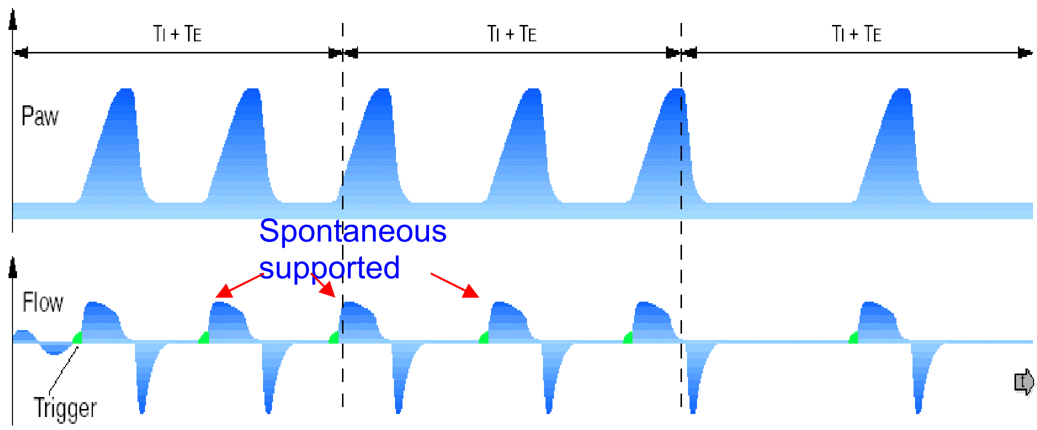
Synchronised intermittent mandatory ventilation (SIMV)

SIMV is viewed as an assisted mechanical rate combined with spontaneous breathing. With SIMV, a rate is set of how many breaths in one minute the clinician would like synchronised with the baby's spontaneous breaths.
This helps to synchronise **some** of the infant's spontaneous inspirations and prevents the baby from 'fighting' the ventilator.
In between mechanical breaths, the infant may breathe spontaneously from the background flow of gas provided. However, these spontaneous breaths in excess of the set rate are not supported by the ventilator and can result in uneven tidal volumes and higher work of breathing.



Assist Control (AC) Ventilation

Unlike SIMV, a synchronized breath is delivered **EVERY** time a spontaneous patient breath meeting the threshold criteria (as per trigger setting) is detected - **Assist**. A minimum back-up rate is set by the clinician, to provide continued support if the infant becomes apnoeic - **Control**.
This back up rate **should not** be set at more than 40 breaths/minute in a spontaneously breathing infant.
Assist Control mode of ventilation results in a potentially uniform support with a reduced work of breathing. Please refer to 'Guideline for Assisted Ventilation' for more information.



Pressure support ventilation (PSV)

In this mode, the patient breathes spontaneously and controls the breathing rate, length of inspiration, and length of expiration. A variable pressure setting allows the clinician to augment spontaneous inspiratory efforts over a wide range of pressures. The tidal volume generated in this mode is a result of the interaction between the patient and the pressure support setting.

This mode may be used alone, so that all breaths are initiated by the patient and pressure-supported by the ventilator, in combination with volume targeting and in combination with IMV to provide back up, so that the patient continues to receive support during periods of apnoea.

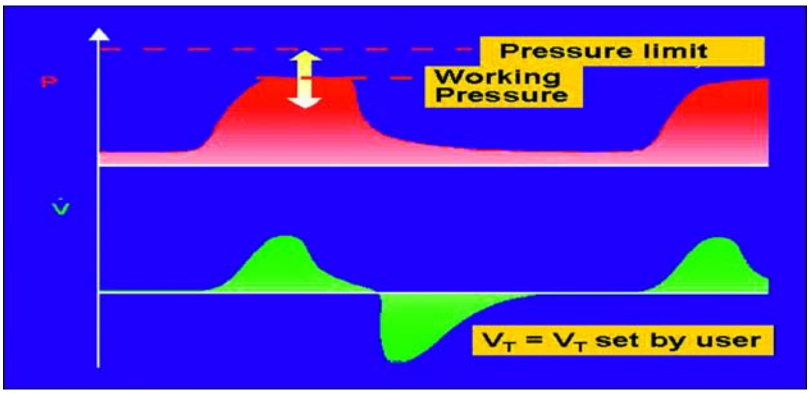
Volume Targeted Ventilation (VG or VLim)

This is an **adjunct** to the usual modes of ventilation and can be used in combination with SIMV or A/C or PSV. Addition of volume targeting ensures that the ventilator delivers a set tidal volume with each breath within the desired pressure limit. This is sometimes also referred to (erroneously) as volume guarantee or volume limited ventilation.

The set tidal volume is determined by the clinician dependent on the infant's gestation, postnatal age and disease condition to achieve target pCO2. The PIP is also set in order to limit the amount of pressure that can be used by the ventilator to achieve the pre-set tidal volume.

Animal studies have shown that it is mainly changes in lung volume (and not pressure) that cause lung injury. Excessive tidal volumes can worsen clinical and pathological evolution of respiratory distress syndrome. Thus potential clinical advantages of volume targeting include:

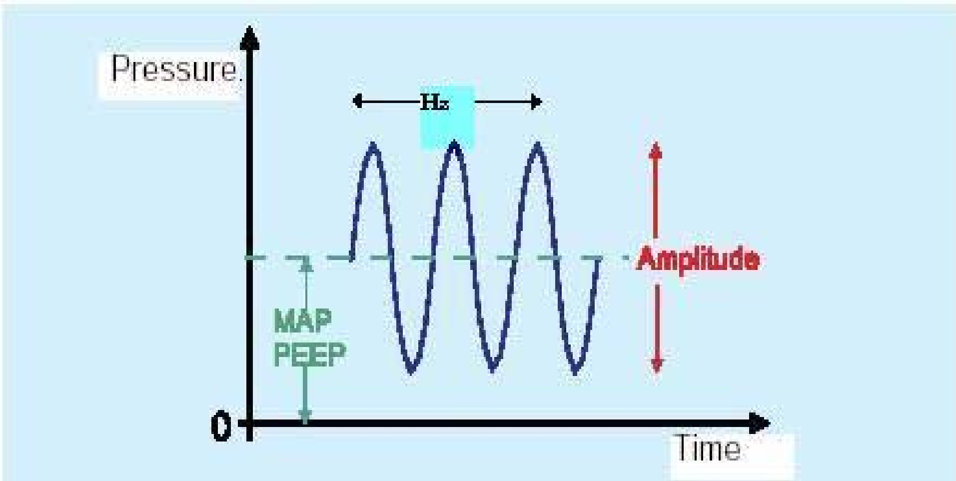
- Maintenance of relatively constant tidal volumes
- Prevention of over distension and volutrauma after surfactant treatment
- Response to sudden changes in compliance
- Stabilization of minute ventilation



Please refer to 'Guideline for Volume Targeted Ventilation' for more information.

High Frequency Oscillation Ventilation

High-frequency ventilation has become increasingly popular in ventilation of the newborn over the past several years. Several techniques may be useful in administering high-frequency ventilation. High-frequency positive pressure ventilation (HFPPV) is defined as conventional positive pressure ventilation at ventilator rates higher than those normally used. The system used in NICU JHCH is high-frequency oscillation (HFO), which delivers very small volumes at extremely high frequencies.



Amplitude

HFOV is more dependant on amplitude than rate. The amplitude is the size of the breath being delivered. The proper setting of amplitude is by observing the infant's chest movement and aiming to have a setting that vibrates the thorax from the nipple to the umbilicus. Changes in amplitude may require readjustment of the mean airway pressure.

Frequency (Hz)

The frequency, which is similar to the rate, is set in hertz (Hz). It is the speed at which the breaths are delivered. To calculate the ventilation rate multiply the Hz by 60.

For example an infant on HFOV set at 15Hz
(60 x 15= rate of 900).

Generally the initial Hz are set anywhere between 10-15. The Hz used may be lower of term or large babies, and higher for preterm or smaller babies.

Mean Airway Pressure

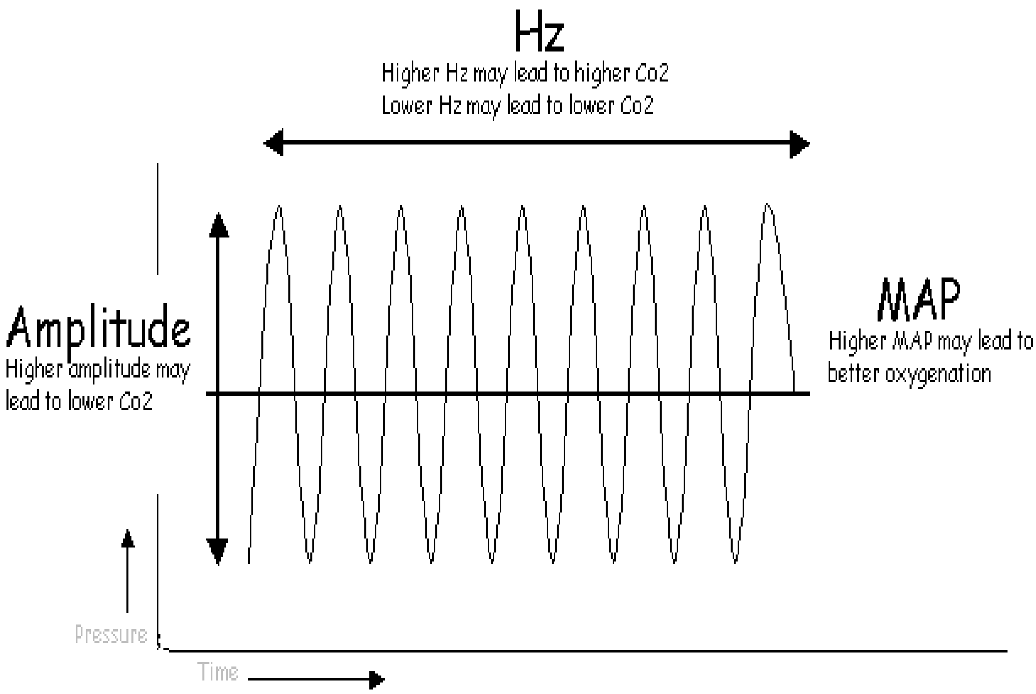
The MAP is similar to the PEEP on conventional ventilators. Optimal MAP is the lowest point at which close to maximum lung recruitment occurs. MAP may sometimes also be known as the distending pressure.

Adjusting the settings

Ventilation parameters are always adjusted by the Medical Officer (MO) responsible for the baby at the time. The RN may take a blood gas, and will show the results to the MO as well as discuss the baby's clinical picture and physical response to the current ventilation settings. The MO may then make changes to those settings if deemed appropriate.

It is very much good nursing practice to understand each setting and the effect it may have on the overall respiratory status of the baby in their care. HFOV is quite different to SIMV or Assist Control, and thus the settings are also different and may be changed or adjusted differently.

An example of some of the effects that may occur with changes to each parameter on HFOV are below.



Recruiting after suction or disconnection

Whenever HFOV is disconnected from the patient the lungs will deflate and lose volume. When the patient is reconnected to HFOV the lung volume will increase again but will not reach the same volume before the HFOV was disconnected, this is due to hysteresis in the lung. On SIMV the repeated PIP re-inflate the lung quickly but on HFOV there is no repeated peak pressure and therefore lung volume is not re-established quickly. To re-establish the lung volume quickly a "recruitment manoeuvre" is required. This provides a higher pressure than the MAP with a long inspiratory time to re-inflate the lung. This manoeuvre should be done following any disconnection from HFOV (ie after suctioning is completed and after repositioning).

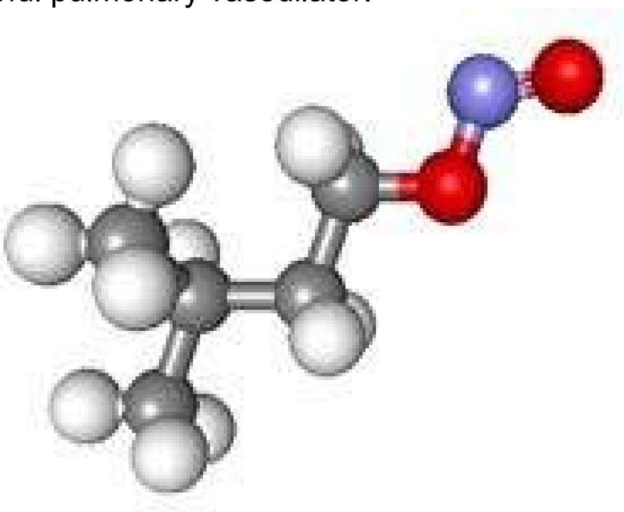
This is done in the following way:

1) Set the Inspiratory Hold Time to 5 seconds. (The inspiratory hold time is set from the options menu).
2) Set the Inspiratory pressure (P Max) 8cm H2O above the MAP)
3) Give a five second inspiration by pressing and holding the Button labelled Insp (top left button with the outline of a red hand on it) until the ventilator starts back on HFOV
4) Repeat the 5 second inspiration 3 times in total at 30 second intervals.

For further instructions or clarifications see Stephanie Manual.

Using Nitric Oxide

Nitric oxide is a colourless, odourless toxic and non-inflammable gas that can be administered via the ventilator circuit as an additional therapy. It is a powerful pulmonary vasodilator.



Nitric Oxide Molecule

Nitric Oxide (NO) (endothelium-derived relaxing factor – EDRF) an endogenous gaseous free radical in the lungs, regulates pulmonary artery tone in utero and after birth. **Exogenous NO reduces pulmonary vascular resistance** during the perinatal period by directly activating soluble guanylate cyclase resulting in increased levels of cyclic-GMP in vascular smooth muscle cells[7]. This results in vascular relaxation by prohibiting myosin protein cross-bridge formation in smooth muscle. In NICU, Nitric Oxide is used primarily in treating pulmonary hypertension.

Treatment with Nitric Oxide is initiated by medical staff after consultation with the Neonatologist.

Please Note :

1. In term infants, this is now considered a recognised practice.

2. Caution should be exercised before using in preterm infants. Benefit of Nitric Oxide in preterm infants has not been proven by randomised studies. Consent should be obtained before using Nitric Oxide in babies < 32 weeks gestation.

Precautions

- **Infant's requiring NO are very sensitive to changes in NO delivery.**
- The half-life of NO is 3-6 seconds, therefore disconnections or interruptions to the circuit should be avoided which may alter the infant's respiratory stability.
- NO is an inhibitor of platelet function. Caution when infant is thrombocytopaenic or has other coagulation factor irregularities.
- Nitric dioxide is a by-product of NO inhalation. Nitric Dioxide may be harmful in large quantities, however more nitric dioxide is expelled from a car exhaust system than from a ventilation set-up. Nevertheless, to protect the infant's carers, the expiratory gases are removed via the internal 'scavenger' system of the ventilator.

Inovent Delivery System for Inhaled nitric oxide

Troubleshooting

All ventilation changes should be made by a MO or NNP. The following table is a guide only of possible solutions for different respiratory problems that may arise.

PROBLEM	POSSIBLE SOLUTIONS	COMMENTS
Low oxygenation	Increase Fi02	The easiest solution (Note that when a baby requires a significant increase in Fi02, the MO or NNP should be notified and a CXR should be considered)
Low Pa02 or saturations	Increase the MAP	May be achieved by increasing the PIP or the PEEP (Changing either of these will affect ventilation also)
High oxygenation	Decrease the Fi02	The easiest solution (Unless the baby is in room air, in which case high Sa02 are acceptable)
High Pa02 or saturations	Decrease the MAP	May be achieved by decreasing the PIP or the PEEP
Over Ventilated	Decrease the tidal volume	Reduce the PIP (Look at the tidal volume to help you decide how much to reduce the PIP by)
High pH with low C02	Decrease the PIP	Will also decrease the tidal volume. (Look at the tidal volume to help you decide how much to reduce the PIP by)
Under Ventilated	Increase the tidal volume Increase the frequency	Increase the PIP until good chest movement is achieved (Look at the tidal volume to help you decide how much to increase the PIP by) Remember that if you are having to put the PIP up a lot, compliance may be going down – look at the infant, the air entry and obtain CXR Increase the rate. If the rate is already approx 60, consider HFOV

COMPLICATIONS OF MECHANICAL VENTILATION

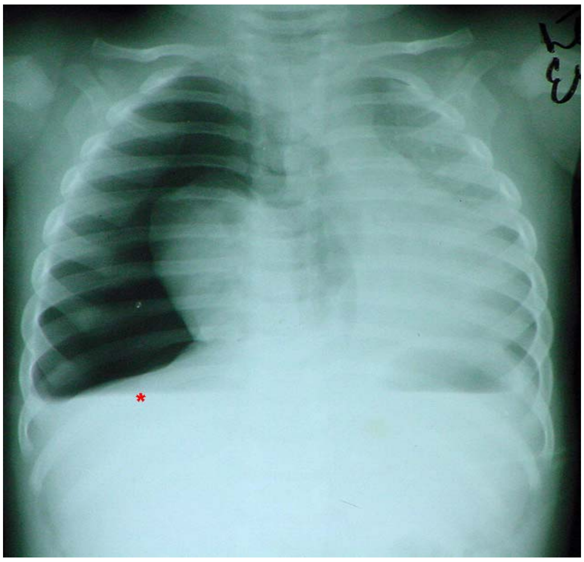
The major complications associated with any application of positive pressure to the airways are barotrauma and cardiovascular depression.

Pulmonary barotrauma and air leaks (includes pneumothorax, pneumomediastinum, pulmonary interstitial emphysema - PIE)
Pulmonary barotrauma usually results from the application of positive pressure or mechanical ventilation. Less common air leaks include pneumopericardium and pneumoperitoneum. The most common risk factors for air leak include lung immaturity, RDS, aspiration syndromes, inadvertent intubation of one bronchus, mechanical ventilation, and CPAP. With the advent of exogenous surfactant one must observe the changes in lung compliance after instillation of surfactant and alter positive pressure support appropriately to prevent a pneumothorax.

- **PIE** occurs when air is present outside the normal airways. Preterm infants with RDS have a higher incidence of PIE than do full-term infants, which may be related to the increased distance between the alveoli and capillaries in these infants. PIE may present alone or may develop into pneumomediastinum or pneumothorax. PIE causes compression of pulmonary vessels, resulting in decreased pulmonary blood flow and increased pulmonary vascular resistance, and causes compression of lymphatic vessels, resulting in increased lung water. PIE initially presents on chest x-ray as nodular, irregular "bubbles" originating in the hilar areas and radiating outward.

- **Pneumomediastinum** may also occur for no known reason or as a sequela of PIE. In pneumomediastinum, a large air collection above the diaphragm may also compress alveoli and prevent inflation. Usually, however, mediastinal air ruptures into the pleural space and results in pneumothorax.

- **Pneumothorax** is an accumulation of air in the pleural space, between the visceral and parietal layers of the pleura, due to distention and rupture of normal alveoli. When pneumothorax occurs in association with PPV, the pleural air is under considerable pressure, resulting in the formation of a *tension pneumothorax*. Chest x-ray films for pneumothorax should be taken on expiration. A dense, dark area separating the lung from the chest wall, with absent lung markings, represents air in the pleural space.



Chest X-Ray showing R sided pneumothorax

The effects of a pneumothorax primarily depend on its size and on the pressure of the air in the pleural space. Pneumothorax causes an increased pleural pressure, compression of the great veins, increased pulmonary vascular resistance, and decreased lung volume. A decrease in venous return occurs, causing a decrease in cardiac output. A sizeable tension pneumothorax is a ***life-threatening condition*** and warrants immediate removal of the extraneous air.

Alterations in Blood Flow

Mechanical ventilation can increase the mean intrathoracic pressure, thereby reducing venous return, and leading to reduced cardiac output.

In addition, reduction of venous return from the head can result in increased risk of intracranial bleeding, particularly in very premature infants who are susceptible to intraventricular haemorrhage.

Airway Damage

Tracheal trauma secondary to a difficult intubation, or after requiring prolonged ETT use. Airway damage can also be as a result of requiring frequent suctioning.
Mechanical ventilation may also lead to volutrauma / barotrauma of the lung tissue.

Infants requiring mechanical ventilation – What is the RN's role?

It is the policy of the JHCH NICU to have a pre- checked ventilator set-up at each admission bed in Level 3. The ventilator should be set-up and checked by two registered nurses (RN's) as per Clinical Practice Guideline number 5.5.1.4 (a)

The RN caring for the intubated and ventilated infant must have an understanding of the pathophysiology of lung disease and it's progression, as well as an understanding of the equipment being used and how changes in ventilation will affect the infant. She/ he must ensure adequate care to maintain patency of the airway by;

- ❖ Positioning the endotracheal tube (ETT) effectively, ensuring it is not 'kinked' or bent.
- ❖ Ensure the Neobar is secure on the infant's face
- ❖ Ensuring the ETT is secure and not loose, causing movement and friction to airway.
- ❖ Ensuring the ETT is curved 'downward' to prevent pressure.
- ❖ Record level of ETT at nares or lips and maintain this position and maintain.
- ❖ After intubation and stabilisation, cut the ETT to a length of 4-5cm from lip/nares to limit amount of deadspace.

Respiratory assessment should be carried out frequently and includes:

1. Visual assessment of;

- ❖ Infant's chest movement or oscillation - ensuring the mechanical ventilation is adequately distending the lungs and is equal between left and right sides.
- ❖ Signs of cardiac compression (BP, perfusion etc)
- ❖ Signs of respiratory deterioration

- Agitation or unsettledness – can sometimes mean that tube may be blocked dislodged

2. Auditory assessment- listening for-
- air leaks
- expiratory grunting
- equal air entry to both lungs via ETT

3. Invasive and non invasive monitoring
- Arterial blood gas values
- Transcutaneous oxygen and carbon dioxide values
- Oximetry
- Chest X-ray- review previous X-Rays

Please Note –

When nursing an infant on any form of respiratory support, it is essential that surveillance and close clinical assessment is provided at ALL times. This means that it is imperative that the RN caring for the infant is in the vicinity at ALL times. Alarms need to be answered, monitored and early intervention provided when problems arise.

This reduces the risk of long term sequelae.

This becomes even more important when the infant is intubated, ventilated and muscle relaxed. **THE RN MUST BE PRESENT AT ALL TIMES.**

The Stephanie Ventilator

JOHN HUNTER CHILDREN'S HOSPITAL (NICU)
PROCEDURE

SUBJECT: ASSEMBLY OF CIRCUIT FOR VENTILATOR

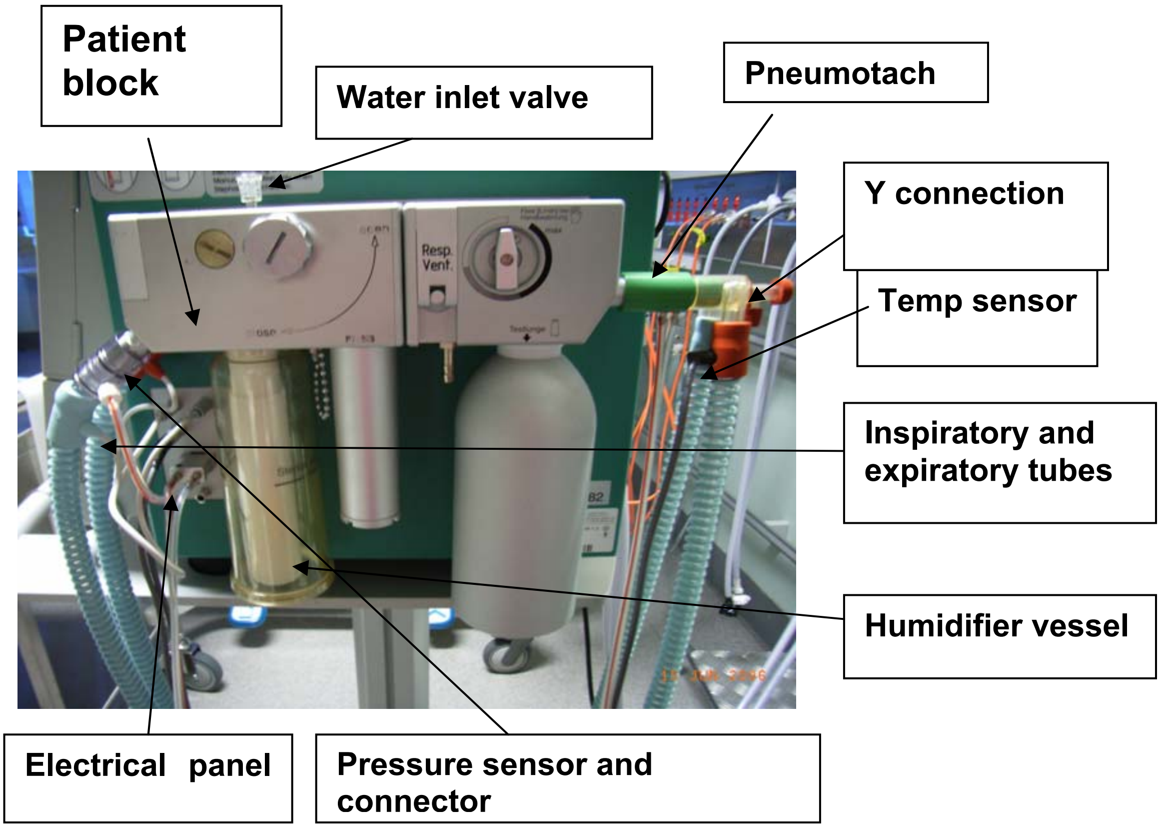
A complete Ventilator circuit should be assembled and ready for use at all times.

Equipment required:

- Ventilator
- Sterile circuit and patient block
- 1L bag of sterile water
- Water feed tubing and syringe
- Bung

Procedure :

- The patient block and circuit will come from CSSD in a wrap contained in the box.
- Screw the patient block onto the side of the ventilator. Make sure it's pushed in properly. Ensure the chain is inserted into the block.



- Screw humidifier chamber into patient block.
- Attach an IV bung to water inlet valve. **Prior to use, fill with water to the black line.**
- Attach the inspiratory (red end) tube to the block. Attach the expiratory tube first to the clear connector that has the pressure sensor (smaller, clear tubing) and then into the patient block.
- Attach the temperature sensors to the inspiratory tubes by pushing it into the holes at the Y-piece and at the junction of the two tubes.
- The pneumotach may have twin pressure tubes attached, but if not, ensure red lined pressure tube attaches to the pneumotach outlet marked with a black dot. Then attach the metal end of the twin tubes to the ventilator via the electrical panel.
- Attach the pneumotach to the patient Y connection.
- Connect the pneumotach to the test lung of the ventilator.
- The ventilator circuit should now be complete.

Performing Ventilator Check

- Obtain second RN to check with you.
- Ensure ventilator connected to power.
- Turn ventilator on using on/ off switch on back of ventilator.
- Connect air and oxygen tubing from Stephanie to wall outlets.
- Turn the dial on the far left to 'TEST' to ensure the Stephanie performs it's self-test.

- Press rotary knobs as prompted to acknowledge 'questions' the machine presents to you.
- At the conclusion of the self-test, the machine will have 'READY FOR USE' on the screen.
- Turn knob to 'OFF' if not required immediately. Both RN's sign a piece of paper with time and date to indicate that ventilator has been checked. Tape note to side of ventilator.
- If ready to use ventilator immediately, turn knob to either 'SIMV' or 'ASSIST/CONTROL' for conventional ventilation.
- Ensure Temperature Differential is zero

Moving to High Frequency Oscillation Ventilation (HFOV)

- Turn Pop-Off dial fully clockwise
- Set F (Hz) knob to 12 (or the Hz that are ordered by the MO)
- Set HFO (Amplitude) knob to zero
- Ensure the chain is inserted in the block
- Turn left hand knob to CPAP
- Press square HFO button until button lights up
- A message will appear stating " **check PIP and PEEP, MAP setting"**
- Press **OK**
- Go to Alarm limits and press twice to reset the alarms
- Go to Alarm Limits scroll to and select P-Mean Follow ON. This will automatically adjust the P-Mean and MAP alarm settings every time you increase or decrease your MAP settings. You can change the 02 alarm the same way so that it doesn't alarm every time you make an adjustment.
- Adjust PEEP to desired level (usually 2-3 above MAP on conventional ventilation)
- Increase amplitude until good chest oscillation is achieved to the level of the umbilicus.
- Change Temperature Differential to +2.5
- Ensure Inspiratory Time is set at 5 seconds.

Turning OFF HFOV

- Immediately wind down PEEP
- Press the HFO button until light goes off
- A message will appear stating "**Check PMAX, PEEP and PIP limit settings"**
- Press **OK**
- Change left hand knob to 'SIMV' or 'ASSIST/CONTROL'
- Change Pop-Off dial back to 40cm H20
- Change Temperature Differential back to zero

- **The set up should be dated and changed on a weekly basis.**

Problem Based Learning

Scenario 1

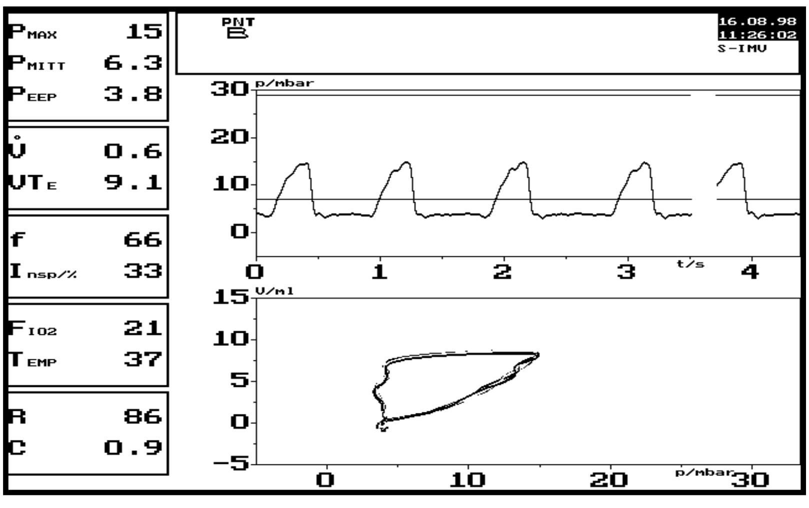
Baby 'Paul' is ventilated using SIMV.
PIP -25
PEEP -5
Rate –40.
The baby suddenly becomes bradycardic and cyanosed.

a) Give three possible causes for this deterioration.

b) Outline a plan of action for each cause.

Scenario 2

Baby 'Jessica' is also ventilated using SIMV. When you arrive for your shift, you notice the volume/pressure curve on the screen.



a) What information can you obtain from the volume pressure curve?

____

____

b) How does that information impact on the care of Baby Jessica?

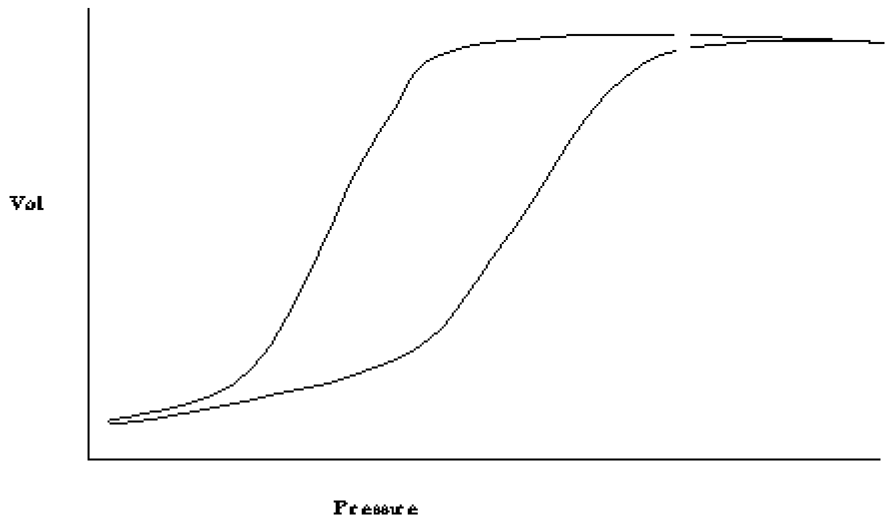
____

____

____

____

c) After some ventilation changes, you note the following curve on the lower Stephanie screen –



What does it tell you about Jessica's ventilation?

____

____

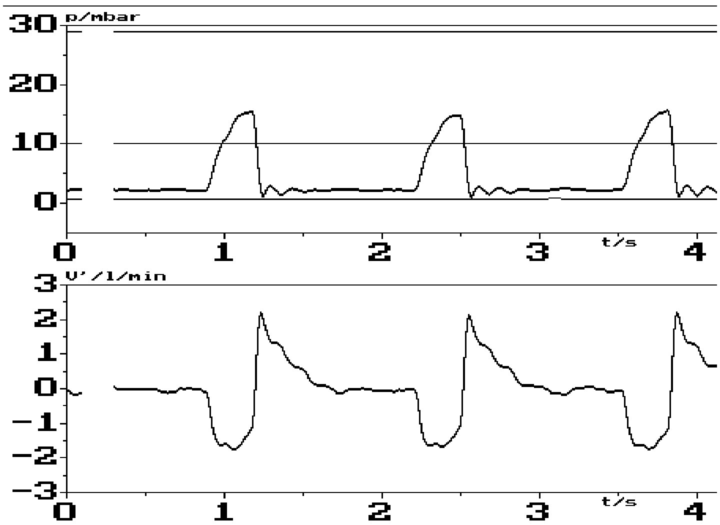
____

____

Scenario 3

Baby 'Russell' is ventilated using Assist/Control mode.

a) What is the importance of the trigger setting?



b) When looking at the Stephanie screen, you notice the above pattern. What do you think might be wrong with the waveform ?

Scenario 4

Baby William is a 24-week neonate ventilated on HFOV.

a) Describe the mode of action of HFOV.

b) Describe how to access the HFOV mode on the Stephanie ventilator.

___

While ventilated on HFOV, Baby William's settings are
Amplitude - 20
Hz - 12
Mean Airway Pressure - 10.

c) Define amplitude and frequency (Hz).

___

Baby William's ABG at 10am reads:

Ph	**7.12**
PaCO2	**75**
PaO2	**50**
HCO3	**24**
BE	**-2**

d) Outline what ventilator changes might be required to correct this blood gas.

___

After 4 hours, it is time to do Baby William's cares and suction.

e) Why is it necessary to perform the recruitment manoeuvre when on HFOV after every suction or disconnection of the ETT?

At 1300, you are ready to go to your lunch break.

f) What nursing considerations do you need to attend to before leaving Baby William?

When you return from your break, you note that Baby William is desaturating and that his HR has fallen to 100.

g) What are your immediate actions?

h) William's ETT is sitting at 6cm at his lips. What do you do?

The medical team elect to use Volume Targeted, Pressure Limited ventilation. They ask you to swap the mode.

i) What are your immediate actions?

j) After several hours, you take a blood gas. You note that William's CO_2 is now 84. What parameters could be adjusted to rectify this?

References:

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4. Noack. G., (1993) Ventilatory treatment of neonates and infants. Servo library. English. Art. No: 6142173 E310E

5. Verklan.M.T.,& Walden.M., (2010) Core Curriculum For Neonatal Intensive Care Nursing. 4th Ed. Saunders Elsevier (USA)

6. Sabella, J. (2003) High Frequency ventilation of Pediatric and Neonatal patients http://www.continuing education.com/nursing/ventilation/index.html

7. Mayock, D.E. (2000) Persistant Pulmonary Hypertension of the Newborn NICU WEB University of Washington Academic Medical Centre.

8. Taeusch. H.W & Ballard. R.A., (1998) Avery's disease of the newborn. (7th ed); W.B. Saunders Co. :Philadelphia

Resources:

Stephanie – Pediatric Ventilator Operating Instructions info@stephan-gmbh.com

Learning Package Evaluation Form

Please circle your response to the following questions:

1. The aims and objectives of the learning package were clear and appropriate to your learning needs and goals? Yes No

2. I have achieved my learning goals?
Yes No

3. As a result of completing this package I now have a better understanding of ………
Yes No

4. The activities and case scenarios were helpful?
Yes No

5. The package was easy to follow?
Yes No

6. The workload was reasonable?
Yes No

7. The information and skills I can use from the package are:

8. Some suggestions I would like to make to improve the package are:

9. Further comments I would like to make are: