

Principles of Ventilation Section One

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Topics

Section One

- Chronic respiratory failure
- Conditions requiring long term mechanical ventilation

Section Two

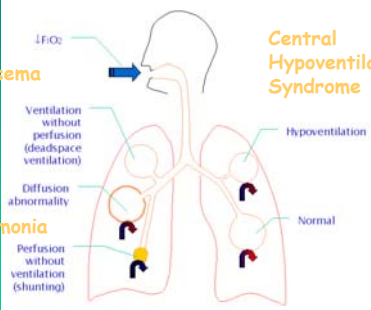
- Basic ventilatory concepts
- Modes of ventilation

Respiratory Failure

- Inadequate gas exchange with:
 - increase in carbon dioxide (hypercarbia)
 - decrease in oxygen (hypoxia)
 - in the blood and, therefore, body tissues
- Considered chronic if the condition develops gradually and persists



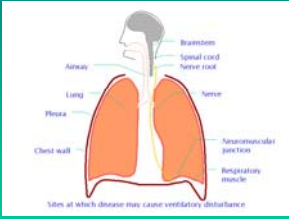
Causes of Respiratory Failure



<http://www.aic.cuhk.edu.hk/web8/respra-1.htm>

Hypoventilation

- CNS abnormality
 - decreased drive to breathe
- Muscle weakness
 - inability to breathe
- Lung or airway disease
 - ↑ work of breathing



<http://www.aic.cuhk.edu.hk/web8/respra-1.htm>

Diseases Needing Long Term Mechanical Ventilation

- Congenital central hypoventilation syndrome
- Neuromuscular diseases
- Spinal cord injury
- Bronchopulmonary dysplasia
- Complex congenital cardiac disease

Congenital Central Hypoventilation Syndrome

CNS abnormality - decreased drive to breathe

- Adequate ventilation when awake
- Hypoventilation when asleep
- Genetic disorder
- Life long need for ventilation
- Can be life threatening



Neuromuscular Diseases

Muscle weakness - inability to breathe

- Spinal muscular atrophy
 - 3 types
 - genetic, motor neuron disease
 - weakness of the voluntary muscles
- Duchenne muscular dystrophy
 - Affects boys in teenage years
 - Progressive weakness



Retrieved from <http://www.rideforlife.com/archives/001030.html>

Cervical Spinal Cord Injury

Muscle paralysis - inability to breathe

- Traumatic injury to spinal cord
 - C5 level or above
 - Tetraplegia
 - Paralysis of diaphragm and accessory muscles



Retrieved from <http://www.case.edu/pubs/cnews/2003/3-20/reeve.htm>

Bronchopulmonary Dysplasia

Lung or airway disease - ↑ work of breathing

Chronic lung disease of infancy

- Most severe require vent
- Caused by lung injury from oxygen & barotrauma
- Can usually be outgrown



Complex Congenital Cardiac Disease

Lung or airway disease - ↑ work of breathing

- Often have cyanotic heart disease
 - unable to adequately oxygenate
- May have ↑ pulmonary blood flow
- May have malacia of the airways



Retrieved from http://www.heartkids.org.au/ball_comedy_details.htm

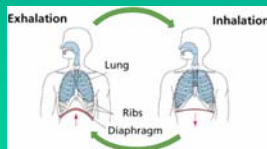
Physiology of Ventilation

Exhaling

- passive process
- diaphragm moves up
- reduces size of chest cavity
- increases air pressure



Inhaling

- active process
- moves diaphragm down
- enlarges size of chest cavity
- reduces air pressure





Physiology of Ventilation

- Volume: amount of air going into the lungs
 - Tidal volume - amount of air inhaled and exhaled with each breath
- Flow: movement of air
 - inspiratory time - length of time for inspiration




Physiology of Ventilation

- Pressure: force need to move the air
 - Two levels of pressure with each breath inspiratory and expiratory
- Minute Ventilation (MV):
 - total ventilation per minute
 - $MV = \text{Tidal volume} \times \text{breaths per minute}$



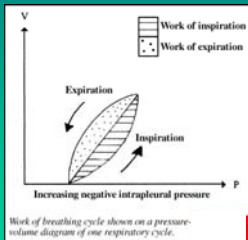
Physiology of Ventilation

- Compliance: the ability of the lung to stretch
 - Higher compliance = easier inflation of the lungs
 - Lower compliance = difficult inflation of the lung
- Airway resistance: obstruction of airflow by the airways
 - diameter of airway determines resistance
 - Smaller diameter = higher resistance



Physiology of Ventilation

- Work of breathing
 - energy needed to overcome compliance of lung and airway resistance
- Represented on a diagram of a pressure-volume curve



Retrieved from: http://www.nda.ox.ac.uk/wfsa/html/v12/v1211_02.htm

Key Points: Ventilation



- Chronic respiratory failure has a variety of causes



- Children require mechanical ventilation for a variety of reasons
 - understand the physiology
 - understand the underlying disease

Principles of Ventilation Section Two

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Topics

- Components of mechanical ventilation
- Basic ventilatory concepts
- Modes of ventilation
- Ventilator alarms
- Trouble shooting problems with the ventilator

Normal vs Mechanical Ventilation

- Normal ventilation
 - Negative pressure system
 - Air is pulled into the lungs
- Mechanical ventilation
 - Positive pressure system
 - Air is pushed into the lungs

Mechanical Ventilation

- Long term mechanical ventilation is most commonly delivered by positive pressure,
- Air is delivered into the lungs in one of two ways
 - Non-invasively via mask
 - Invasively via a tracheostomy

Mechanical Ventilator System

- Variety of ventilators
- Regulates
 - flow, pressure, volume
- Use microprocessor technology



Method of Air Flow

- Intermittent flow
 - triggered by patient
- Continuous flow
 - always available to patient



Puritan Bennett/Tyco Achilea P802 Piston



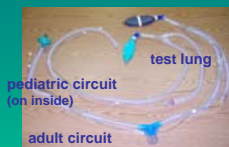
Pulmonetic Systems LTV-1000 Turbine



Newport LF-50 Reciprocating Piston

Mechanical Ventilator System

- Variety of circuits
 - Disposable or non-disposable
 - Heated wire circuit
- Test lung



pediatric circuit (on inside)


adult circuit with water trap (on outside)




heated wire circuit

Humidity

- Heated System
 - AC power source
- Heat Moisture Exchanger (HME)
 - in-line passive humidity



HUDSON Concha III
Heated Humidifier




Fischer & Paykel
Healthcare
MR850 Heated
Humidifier

Retrieved from:
http://www.hudsonrd.com/Products/product_indiv.asp?catalog=1&PageId=258&prod_cat=20&prod_sub_cat=45&mywebsite

Retrieved from:
http://www.pulmonetic.com/patientandfamily/patient_library.aspx?86197959

Definitions and Modes



- **WARNING!**
- There is little standardization of terms on the ventilators
- Some things that are *slightly different* are given the *same names*
- Some things that are the *same* are given *different names*

Breath Types

- Spontaneous Breath
 - Inspiration is both initiated and terminated by the patient
- Mandatory Breath
 - Inspiration is either initiated or terminated by the ventilator

Trigger

- How does the vent know when to give a breath? - "Trigger"
 - patient effort
 - elapsed time
- The patient's effort can be "sensed" as a change in pressure or a change in flow (in the circuit)

What Is a "Mode"?

Mode

- a manner, way, or method of doing or acting, or....
- a given condition of functioning: a status, or..
- how the ventilator gives a breath



Modes

- Control Mode
 - every breath is fully supported by the ventilator
 - preset respiratory rate
 - patient efforts ignored
- AC Assist/Control Mode
 - a minimum set rate and all triggered breaths above that rate also fully supported



Modes

- SIMV Modes
 - Synchronized intermittent mandatory ventilation
 - breaths "above" set rate not supported
 - vent synchronizes the IMV "breath" with the patient's effort



Control of Breaths

Whenever a breath is supported by the ventilator, regardless of the mode, the control or limit of the support is determined by either a preset volume *OR* a preset pressure.

- Volume Control: preset tidal volume
- Pressure Control: preset peak inspiratory pressure

Volume Control


- Set parameter
 - specific tidal volume of air during inspiration
 - The ventilator uses a flow of air for a set period of time to deliver the volume
 - Respiratory rate
- Variable parameter
 - Pressure is a product of lung compliance, airway resistance and flow rate
 - The ventilator does not react to the variable pressures unless the high or low pressure alarm limits are violated
- Good mode to ensure adequate volumes for patients unable to breathe deeply

Pressure Control

- Set parameter
 - Fixed airway pressure
 - Ventilator adjusts flow to maintain pressure
 - Respiratory rate
- Variable parameter
 - Volume delivered depends upon the inspiratory pressure and time, pulmonary compliance and airway resistance
 - Delivered volume can vary from breath-to-breath
 - Low minute volume alarm warns of low volumes
- Good mode to use if patient has large air leak
 - Ventilator will increase the flow to compensate


Pressure Terms

- Peak Inspiratory Pressure (PIP)
 - Maximum pressure measured by the ventilator during inspiration
- Pressure Support (PS)
 - amount of pressure applied to the airway during spontaneous inspiration by the patient
 - helps to overcome airway resistance and inadequate pulmonary effort and is added on top of the PEEP during inspiration
 - increased flow during inspiration to reach the target pressure to make it easier for the patient to take a breath




Pressure Terms

- Continuous positive airway pressure (CPAP)
 - amount of pressure applied to the airway during all phases of the respiratory cycle
 - can maintain oxygenation and decrease work of breathing
 - no cycling of pressures - patient initiates all breaths



Positive end-expiratory pressure (PEEP)

- Pressure present in the airways at the end of expiration
- Used to help prevent alveolar collapse at end inspiration
- Can stent open floppy airways



Pressure vs. Volume

- Pressure
 - tidal volume may change suddenly as patient's compliance changes
 - can lead to hypoventilation or overexpansion of the lung
 - if trach is obstructed acutely, delivered tidal volume will decrease
- Volume
 - no limit per se on PIP (usually vent will have upper pressure limit)
 - constant flow pattern results in higher PIP for same tidal volume as compared to Pressure modes

Ventilator Alarms

- Low pressure
- High pressure
- Low volume
- High volume
- Change in power (to a lesser power source)
- Low power



Low-Pressure Alarms Volume Mode

- Patient disconnection
- Circuit leaks
- Airway leaks
- Use test lung



High-Pressure Alarms

Volume Mode

- Patient coughing, talking or fighting the ventilator breaths
- Secretions or mucus in the airway
- Reduced lung compliance (may be due to pneumothorax or pneumonia)
- Increased airway resistance
- Accumulation of water in the circuit
- A kink in the ventilator circuit

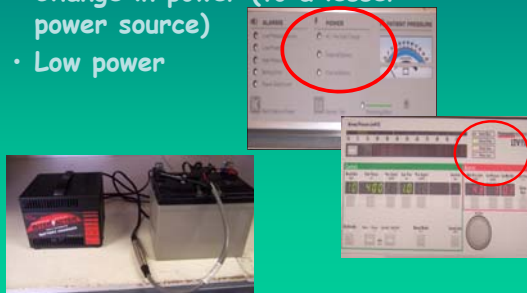
Volume Alarms

Pressure Mode

- More difficult to have accurate alarms in pressure mode
 - ventilator may continue to deliver breaths despite disconnection from ventilator
- Volume alarms can alert to changes in volume indicating inadequate ventilation


Power source alarms

- Change in power (to a lesser power source)
- Low power



Ventilator Troubleshooting

• Determine what is the problem ?

-  at the patient !!
- Listen to the patient !!



-  at the ventilator!!

- Check settings, readings and alarms

Ventilator Troubleshooting

- When in doubt.....
- DISCONNECT THE PATIENT FROM THE VENTILATOR and begin bag ventilation
 - Eliminates the vent circuit as the source of the problem
- Giving breaths with the resuscitation bag...

- Helps you identify airway issues
- Provides ventilatory support to the child while you identify the problem



Weaning

- Is the cause of respiratory failure gone or getting better ?
 - Children with chronic lung disease most likely to wean
 - Children with neurological involvement least likely to wean




Weaning

- Decrease vent settings
 - decrease the PEEP (4-5)
 - decrease the rate
 - decrease the PIP (as needed)
- Decrease time on the vent

Weaning

- Can the child can make up the difference?
- Is the child well oxygenated and ventilated?
- Can the child tolerate the increased work of breathing?

Key Points: Ventilation

-  • The most common mechanical ventilation is a positive pressure system
-  • Understand the specifics of the ventilator in use
 - Brand
 - Circuit
 - Mode & settings
-  • When in doubt, **DISCONNECT THE PATIENT FROM THE VENTILATOR** and begin bag ventilation
