Principles of Ventilation Section One

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Topics

Section One

- Chronic respiratory failure
- Conditions requiring long term mechanical ventilation

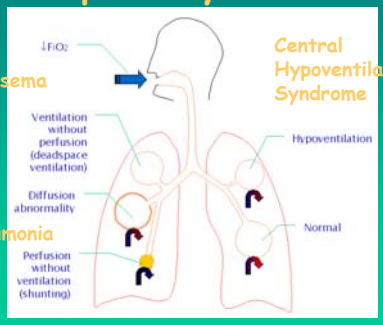
Section Two

- 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/respfa~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/respfa~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

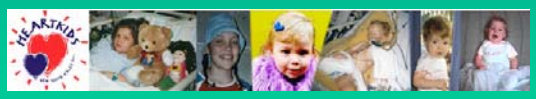
Lung or airway disease - ↑ work of breathing

- 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

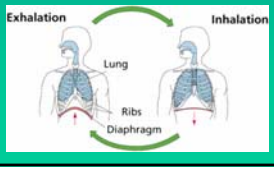
- Often have cyanotic heart disease
  - unable to adequately oxygenate
- May have ↑ pulmonary blood flow
- May have malacia of the airways



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

Physiology of Ventilation

Exhaling	Inhaling
- passive process	- active process
-diaphragm moves up	-moves diaphragm down
-reduces size of chest cavity	-enlarges size of chest cavity
-increases air pressure	-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 = Tidal volume x breaths per minute

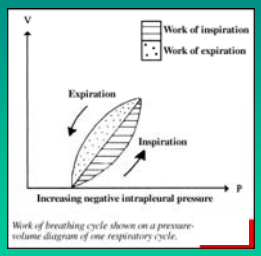
Physiology of Ventilation

- 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



Work of breathing cycle shown on a pressure-volume diagram of one respiratory cycle.

Retrieved from: http://www.nda.ox.ac.uk/wfsa/html/u12/u1211_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

Mechanical Ventilator System

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

heated wire circuit

Humidity

- Heated System
  - AC power source

HUDSON Concha III Heated Humidifier

- Heat Moisture Exchanger (HME)
  - in-line passive humidity

Retrieved from: http://www.hudsonrci.com/Products/product_indiv.asp?catalog=1&PageId=259&prod_cat=20&prod_subcat=85&keywords=

Fischer & Paykel Healthcare

MR850 Heated Humidifier

Retrieved from: http://www.pulmonetic.com/patientsandfamilies/patient_library.aspx?861979539

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*

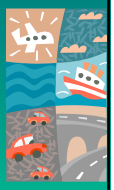
Breath Types

- 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"?

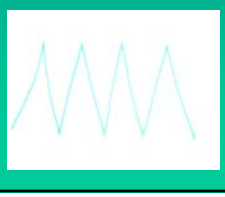


Mode

- 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

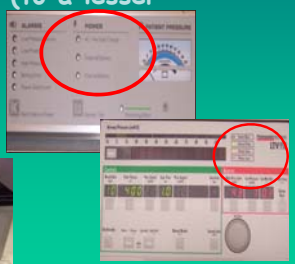
- Patient coughing, talking or fighting the ventilator breaths
- Secretions or mucus in the airway
- Reduced lung compliance (may be due to pneumothorax or pnueumonia)
- Increased airway resistance
- Accumulation of water in the circuit
- A kink in the ventilator circuit

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 ?
  - LOOK at the patient !!
  - Listen to the patient !!

  - LOOK 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