Ventilation for Inpatient Nursing

Created by BC Children's Medicine Inpatient CNE's & Critical Care RRT's May 2023

Ventilation

- We can ventilate non-invasively or invasively

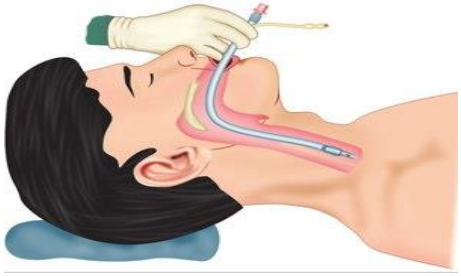
Non-Invasive Ventilation:

Mask

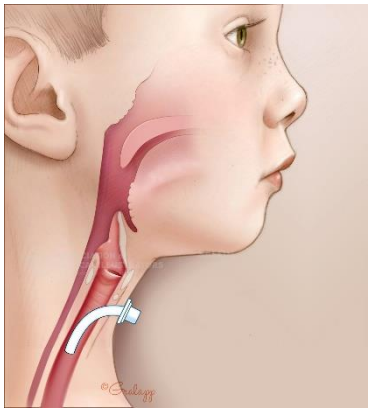
Pillows

Invasive Ventilation:

Endotracheal Tube (short-term)

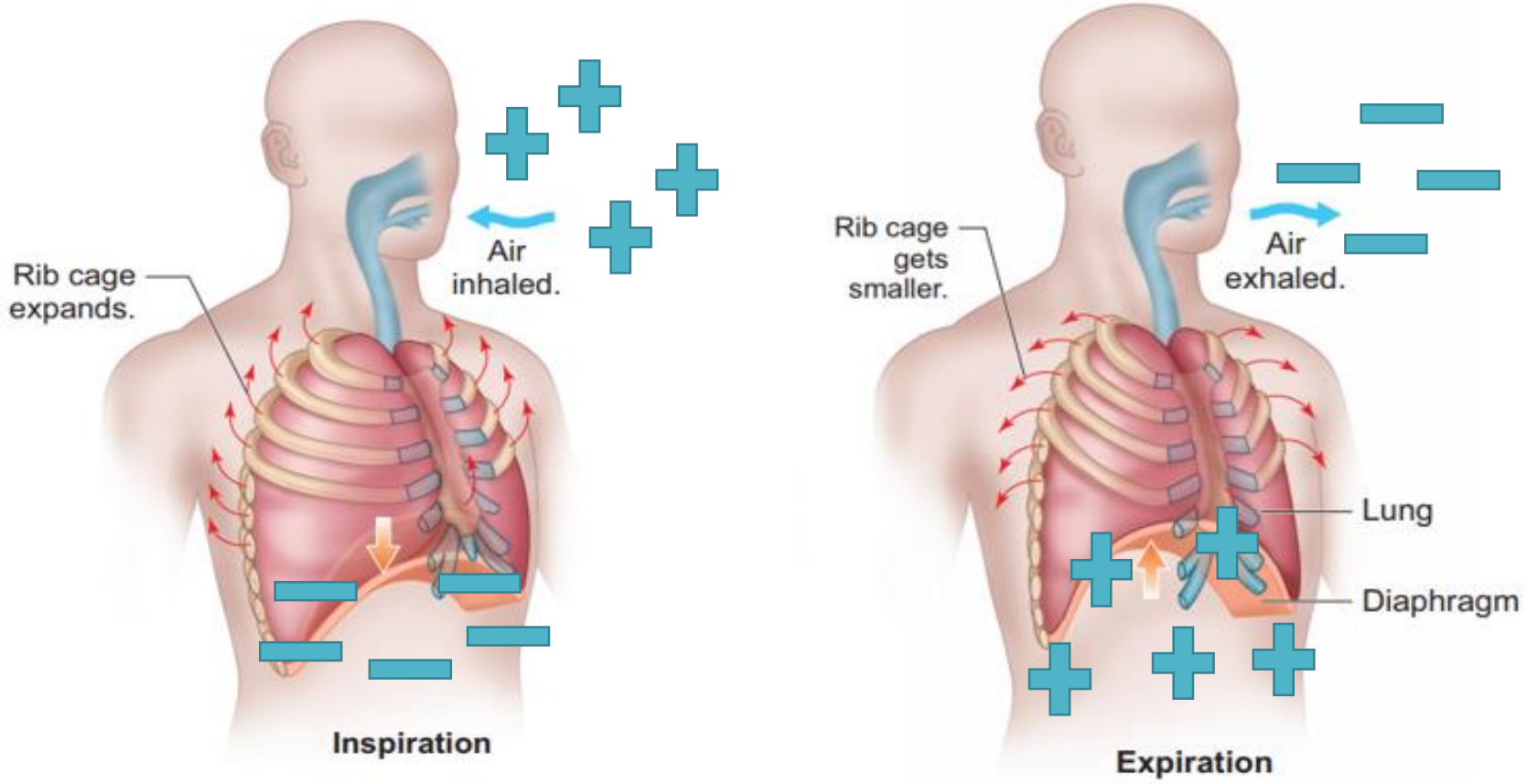


Tracheostomy Tube (long-term)



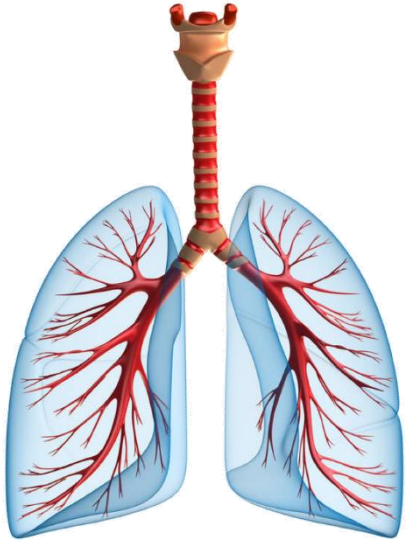
Ventilation Review

- Controlled by pressure gradients between atmospheric air & thorax
- Air travels from an area of high pressure to low pressure



Negative Pressure Ventilation

- This is the way we naturally breathe
- Air gets pulled into our lungs as we inhale



Positive Pressure Ventilation

- A constant pressure is being applied to the person's airway. The pressure increases on inspiration and is decreased on expiration to the lower level that is constantly maintained
- Maintains a pressure in the alveoli at all times to avoid collapse to provide improved gas exchange

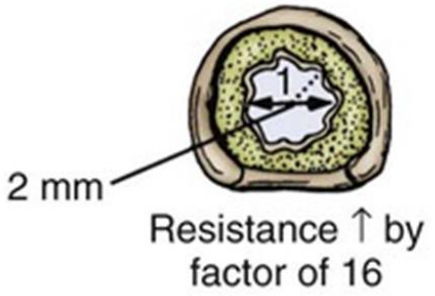
Lung Compliance and Airway Resistance

Lung Compliance: Measure of the lungs ability to stretch and expand

- Increased Compliance: lungs expand easily
- Decreased Compliance: lungs are difficult to expand
- ↓ Compliance = ↑ Work of Breathing

Airway Resistance : Dependent on the diameter of the airway

- This is important is infants and children who have small airways *(Secretions in airway, airway swelling)*
- ↑ Resistance = ↑ Work of Breathing



True or False?

If the patient's lung compliance decreases, their work of breathing will increase.

True or False?

If the patient's lung compliance decreases, their work of breathing will increase.

True

Correct! If the patient's lung compliance decreases, that means their lungs are more stiff and harder to stretch out.

True or False?

During ventilation, pressure and volume will fluctuate depending on the patient's compliance and resistance.

True or False?

During ventilation, pressure and volume will fluctuate depending on the patient's compliance and resistance.

True

If the patient's compliance is decreased (lungs are stiffer) or their airway resistance is increased, you will need a higher pressure gradient to inflate the lungs with the same volume of gas

Pressure Vs. Volume Ventilation

Pressure Ventilation

- What is set: Inspiratory Pressure
- What is variable: Tidal Volume Vt

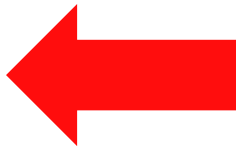
Volume Ventilation

- What is set: Tidal Volume Vt
- What is variable: Pressure

Pressure Vs. Volume Ventilation

Pressure Ventilation

- What is set: Inspiratory Pressure
- What is variable: Tidal Volume Vt



Volume Ventilation

- What is set: Tidal Volume Vt
- What is variable: Pressure

Ventilation Terminology

- Peak Inspiratory Pressure (PIP/IPAP)
- Positive End Expiratory Pressure (PEEP/EPAP)
- Respiratory Rate (RR)
- Inspiratory Time (Ti)
- Tidal Volume (Vte)
- Minute Ventilation (MinVent/VE)

Peak Inspiratory Pressure (PIP)

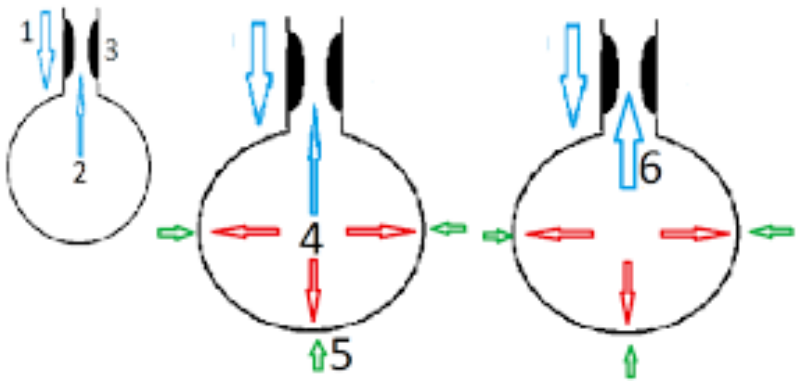
- PIP is the pressure that pushes the air into the lungs during inspiration
- It's the highest level of pressure that will be applied to the lungs during inspiration (measured in cm H_2O)
- It helps to augment the child's own breathing effort in order to deliver an adequate tidal volume.
- The amount of PIP prescribed will depend upon the compliance of the child's lungs and the desired tidal volume for the child.

Positive End Expiratory Pressure (PEEP)

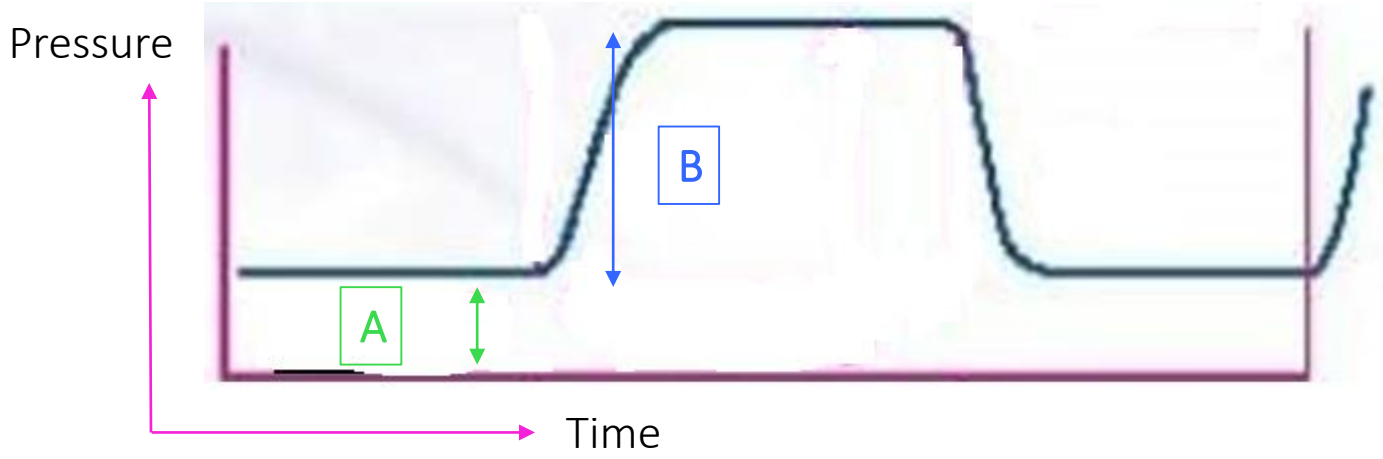
- PEEP is the pressure that is applied to the lungs at the end of expiration (cmH_2O) and continued through until the next inspiration.

- PEEP keeps the alveoli from collapsing on exhalation and prevents atelectasis.

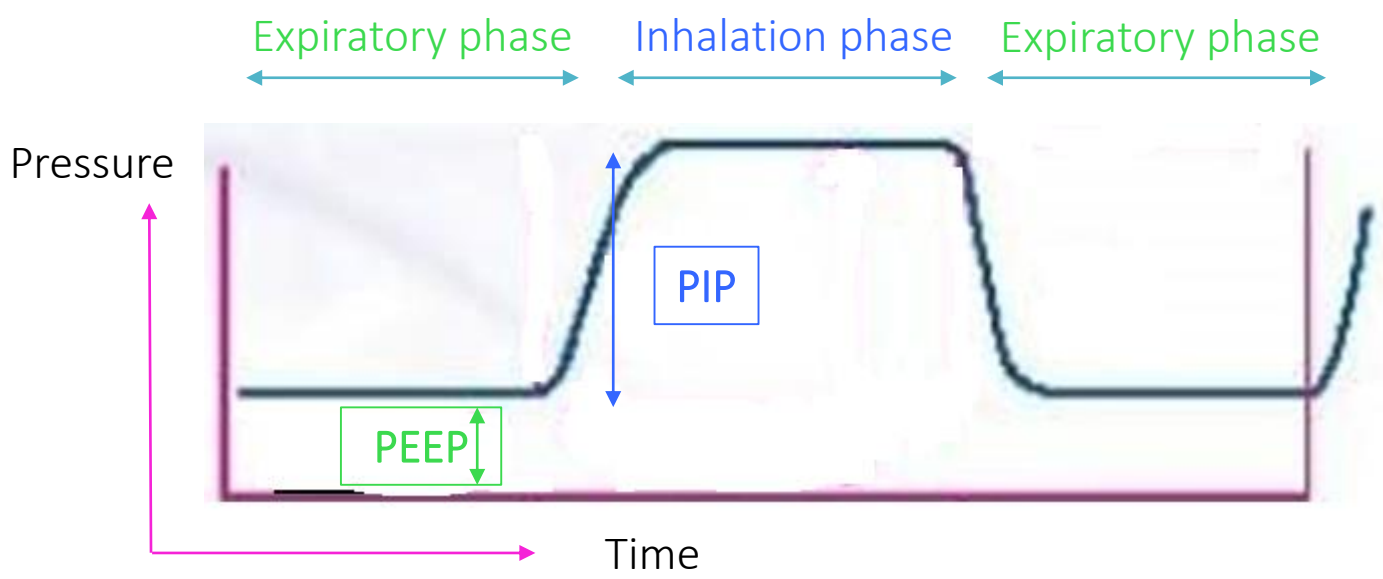
- PEEP also helps to prevent upper/lower airway collapse by stenting the airways open, especially in children who have soft airways e.g. tracheobronchial malacia.



PIP or PEEP?



PIP or PEEP?


Expiratory phase
Inhalation phase
Expiratory phase
Pressure
PIP
PEEP
Time

Respiratory Rate (RR)

There will be a total RR displayed on the monitoring screen of the ventilator which includes the set RR + spontaneous RR

There are 2 types of breaths that are supported by the ventilator:

Spontaneous breaths:
the breaths that are started and ended by the child.

Mandatory breaths:
the breaths that are fully controlled by the ventilator.

Inspiratory Time (Ti)

- This is the length of time that the upper pressure (PIP) will be maintained during inspiration on all mandatory (set) breaths

- Inspiratory time allows the pressure to inflate the lung to allow for improved gas exchange in the alveoli.

  (The more restrictive or stiff the lungs are the longer it will take to inflate.)

- Normal ranges vary with age:

  neonates 0.5 seconds

  older children to a max of 1.2 seconds

How long can you hold your breath?

Tidal Volume (Vt)

Vt is the volume of air that a person typically breathes in and out during a normal breath. An average target Vt is 6-8ml/kg

The tidal volume that a person generates is dependent upon a number of factors:

1. The person's own ability to breathe

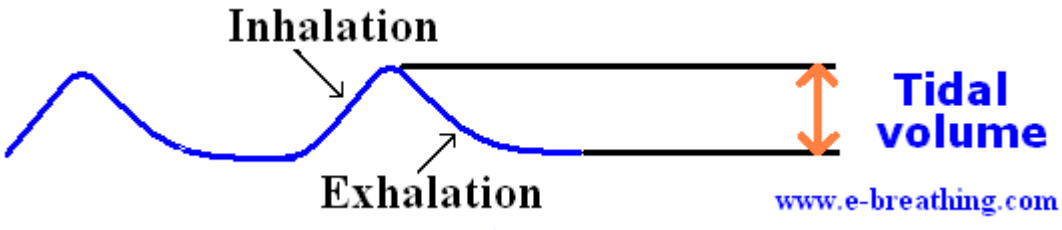
   Muscle strength/function.

2. Lung compliance

   The lower the lung compliance (i.e. the stiffer the lungs/secretions) the smaller the Vt

3. Airway resistance

   The higher the airway resistance, the smaller the Vt



Minute Ventilation

- The amount of ventilation over a minute

  RR x Vt = Minute Ventilation (MinVent)

- This number is monitored as a trend to observe the patient's status and need for suctioning and repositioning

- This number varies, and is a reflection of the patient's metabolic demand
  (ex. MV will be higher if the patient has a fever, is in pain, etc.)

Question!

In which example will a patient receive more **volume** with each breath:

PIP of 15 cm H2O and PEEP of 5 cm H2O

OR

PIP of 10 cm H2O and PEEP of 5 cm H20

PIP of 15 cm H2O and PEEP of 5 cm H2O

The pressure difference of 15/5 is 10 vs. the pressure difference of 10/5 is only 5. A bigger pressure difference delivers MORE volume. This indicates a higher level of support

Modes of Ventilation

(CPAP) Continuous Positive Airway Pressure

(S) Spontaneous

(S/T) Spontaneous/Timed

(PC-SIMV) Pressure Control – Synchronized Intermittent Mandatory Ventilation

(PC) Pressure Control

Continuous Positive Airway Pressure (CPAP) Mode

- With CPAP, there is only one pressure
- The child has full control over every part of the breath

When is CPAP used?

- For children with anatomy that collapses or obstructs their upper airway

Spontaneous (S) Mode

- Patient initiated breaths are supported by a set pressure → helps with inspiration
- No set respiratory rate

When is S mode used?

- For children with neuromuscular weakness who have difficulty taking deeper breaths because of their weak respiratory muscles but have a good respiratory drive

The patient NEEDS to have a respiratory drive….WHY?

Spontaneous/Timed (S/T) Mode

- With ST mode, the ventilator would provide spontaneous support while the child is breathing above the set RR.
- If the child breathes below the set RR, the child will get mandatory breaths at the set RR until they breathe above it.
- This is similar to Spontaneous mode with a back up rate built in

When is ST mode used?

- Who have episodes of apnea or periodic breathing with long pauses between in breaths

Pressure Control (PC) Mode

- This is a controlled mode in which every breath is a set length.

- When/if the child triggers a breath, it will be held for the set Ti.

When is PC mode used?

- For children who require full ventilator support
- For children who have no central control of breathing (i.e. high Spinal Cord injury, brain stem tumour)
- If the child is not able to ventilate well enough with PC-SIMV mode (which we will talk about next)

Note: This mode may feel uncomfortable for some children as the ventilator controls the length of every breath

Pressure Controlled Synchronized Intermittent Mandatory Ventilation (PC-SIMV)

- This is a mix of both S mode and PC mode.

- In between the mandatory controlled rate the child may also take their own spontaneous breaths

This controlled rate gives the child a sigh like breath.

When is PC-SIMV used?

- If a child can breathe spontaneously but requires larger breaths intermittently to maintain lung inflation.

- Often the goal of PC-SIMV mode is to have the patient breathe spontaneously between the mandatory breaths

Use of Modes

NON-INVASIVE VENTILATOR MODES

- CPAP
- Spontaneous
- S/T
- PC

INVASIVE VENTILATOR MODES

- S/T
- PC
- PC-SIMV

Test Your Knowledge…

Nadia is a 3 month old infant who has a history of a stroke post-meningitis and was recently diagnosed with central sleep apnea. Her medical team has decided to initiate positive pressure ventilation for nights/naps.

- What type of ventilation mode would they likely choose and why?

Test Your Knowledge…

Noah is a 2 year old with a progressive neuromuscular disease. Up until now, Noah has never required any respiratory support other than suctioning as needed. Recent sleep studies show Noah is experiencing decreased oxygenation at night. Noah's medical team has decided to start him on positive pressure ventilation for nights/naps.

- What type of ventilation mode would they likely choose and why?

Test Your Knowledge…

Throughout the night you notice Noah's tidal volumes are decreasing. If Noah weighs 20 kg, what should his tidal volumes be?

If Noah's tidal volumes overnight were 80-100 ml, what might be going on? And what would your next steps be?

Measured or Set?

1. PIP
2. PEEP
3. Tidal Volume
4. Respiratory Rate
5. Inspiratory Time
6. Expiratory Time
7. Minute Ventilation
8. Leak

Measured or Set?

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2. PEEP
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1. SET

Measured or Set?

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2. PEEP
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8. Leak

1. SET
2. SET

Measured or Set?

1. PIP
2. PEEP
3. Tidal Volume
4. Respiratory Rate
5. Inspiratory Time
6. Expiratory Time
7. Minute Ventilation
8. Leak

1. SET
2. SET
3. MEASURED

Measured or Set?

1. PIP
2. PEEP
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5. Inspiratory Time
6. Expiratory Time
7. Minute Ventilation
8. Leak

1. SET
2. SET
3. MEASURED
4. SET and/or MEASURED

Measured or Set?

1. PIP
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1. SET
2. SET
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4. SET and/or MEASURED
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Measured or Set?

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1. SET
2. SET
3. MEASURED
4. SET and/or MEASURED
5. SET and/or MEASURED
6. NOT SET or MEASURED

Measured or Set?

1. PIP
2. PEEP
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1. SET
2. SET
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4. SET and/or MEASURED
5. SET
6. NOT SET or MEASURED
7. MEASURED
8. MEASURED

Now that you know ALL of the Terminology….

Let’s move on to the Ventilators

Non-Invasive Ventilators

Trilogy 202

Resmed Aircurve

Resmed Stellar

Mask Station

HTV Team

Home Tracheostomy Ventilation Program

Supports children in BC who have tracheostomies and/or home ventilation.

HTV Team Members:

- 3 physicians
- Nurse
- 2 Respiratory Therapist
- Physiotherapist
- Occupational Therapist

**Not all patients will require these services*

Test Your Knowledge…

Josie is a 6 year old girl with Spinal Muscular Atrophy. She requires BiPAP 16/8 for most of the day, with breaks in the morning and evening. You notice that her monitor is alarming because her heart rate is 130… you go in to assess.

Assessment:

Vital signs: HR 135, BP 120/90, RR 30, SpO2 94%, Temp 36.8

CNS: Quiet, Josie talks at baseline

Resp: Mild subcostal indrawing, shallow breathing

What are signs/symptoms of a patient with neuromuscular disease in respiratory distress?

Nursing Considerations

Know your patient's underlying disease!

Feeding:

Some patients are fully orally fed while others require tube feeds

Followed routinely by HTV OT

Admission Criteria:

Patient Needs Assessment Document

Developmental Impact:

Development may improve with a trach

May be working towards having their ventilation decreased or learning to live with a trach and/or ventilator for their entire life

Include your patient in their care!