Anatomic Components of Respiratory System:

- **Upper Airways**
  - Nasal cavity and pharynx
- **Lower Airways**
  - Larynx, trachea, bronchial tree
- **Lung Lobes**
  - 2 on left, 3 on right
- **Tracheobronchial tree**
- **Alveolar unit**
Nose primary functions:
- Filter
- Humidify
- Warm inspired gas

Pharynx:
- NASOPHARYNX
- OROPHARYNX
- LARYNGOPHARYNX

LARYNX

Framework of nine cartilages held in position by intrinsic and extrinsic muscles.

SINGLE: Thyroid Cricoid Epiglottis

PAIRED: Arytenoid Corniculate Cuneiform

VOCAL CORDS

- Lined by mucous membrane that forms two folds that protrude inward.
- Upper folds are called false vocal cords.
- Lower pair are the true vocal cords.
- Medial border is composed of a strong band of elastic tissue called the vocal ligament.
- Space in between the true vocal cords is called the rima glottidis or glottis.

UPPER RESPIRATORY TRACT

- Lung
- Trachea
- Bronchus
- Diaphragm
- Bronchiole
- Normal Airway Secretions
- Mucous Gland
- Alveolar Sacs & Alveoli
- Terminal Bronchiole
NOTE: The precise number of generations between the subsegmental bronchi and the alveolar sacs is not known.
Schematic drawing of the anatomic structures distal to the terminal bronchioles; collectively, these are referred to as the primary lobule.
Alveolar unit
1. Conducting Zone

- Upper and lower airways
  - Filter, warm and humidify, and conduct gases
- Ventilation = movement of gases, O2 and CO2, in and out of the lungs
- Conducting zone = anatomical deadspace (1/3)
2. Respiratory Zone

- Bronchioles, alveolar ducts, and alveoli
- Alveoli = primary site for gas exchange
- Respiration = exchange of gases between the lungs and blood

Although the respiratory system can be viewed as 3 main components, a functional description is more useful because it distinguishes the process of ventilation from that of respiration. The two functional areas are the **conducting and respiratory zones**. The conducting zone participates in ventilation. Inspired gas is filtered, warmed, and humidified as it enters the lungs. Gas movement in the conducting zone is termed dead space ventilation. Increased levels of dead space can cause the patient to increase their rate and depth of breathing to compensate for the effect on ventilation and respiration.
The exchange of gases between the alveoli and blood is called respiration and occurs in the respiratory zone. This area is comprised of small airways, alveoli, and the pulmonary capillaries. Gas enters the respiratory zone from the conducting airways and blood circulates the alveoli from the pulmonary capillaries. In order to have affective respiration there must be adequate levels of ventilation and pulmonary blood flow.
Pulmonary Mechanics

Respiratory Mechanics
Pulmonary Mechanics

- Requires chest wall (thorax) and respiratory muscles
- Pleura (lining) - lubricant
- Opposing forces keep lungs inflated (thorax=out, lungs=in)
- Muscles provide force (work)
- Diaphragm = major muscle of ventilation
Inspiration (ACTIVE)

Diaphragm contracts - moves downward
Thoracic volume increases
Lung (pleural) pressure decreases - air moves in
Expiration (PASSIVE)

Diaphragm relaxes - moves up
Thoracic volume decreases
Lung (pleural) pressure decreases air moves out

Expiration
- Intra-alveolar pressure below atmospheric pressure
- Intrapleural pressure: progressively decreases
- Diaphragm: progressively moves downward

End-Expiration
- No gas flow
- Intra-alveolar pressure in equilibrium with atmospheric pressure
- Intrapleural pressure holds at a level below that at rest
- Downward movement of diaphragm stops
FIGURE 2-5. How the excursion of the diaphragm affects the intrapleural pressure, intra-alveolar pressure, and bronchial gas flow during inspiration and expiration.
Compliance

- Amount of work required to inflate lungs
  - “how stiff is the lung?”
- Compliance = \[
\frac{\Delta \text{Volume} (\text{L/cmH}_2\text{O})}{\Delta \text{Pressure}}
\]
- Normal = 0.1 L/cmH\text{O} (100 ml/cmH\text{O})
- High compliance easier - to inflate
- Low compliance - harder to inflate
Lung Compliance Changes and the P-V Loop

Overdistension

With little or no change in VT

Paw rises

Volume (ml)

Pressure (cm H₂O)

Normal
Abnormal

Elastance

- Amount of work required to exhale
- Elastance = \( \frac{\Delta \text{Pressure (cmH}_2\text{O/L)}}{\Delta \text{Volume}} \)
- Reciprocal of compliance
- Good compliance = bad elastance
- Bad compliance = good elastance
**Resistance**

- Amount of work required to move air through the lungs
- Resistance = \( \frac{\text{Pressure}}{\text{Flow}} \) (cmH\(_2\)O/L/sec)
- Primarily influenced by airway diameter
- Normal = 0.6 - 2.4 cmH\(_2\)O/L/sec
Ventilation occurs due to a pressure gradient between the lungs and mouth. Contraction of the respiratory muscles results in a pressure-volume change in the lungs. As pressure decreases air moves into the lungs during inspiration, and as lung pressure increases gas moves out of the lungs during expiration. The compliance of the pulmonary system influences the amount of pressure required to affect a volume change. Airway resistance also influences the effort needed to create a volume change.
Lung Volumes and Capacities

Pulmonary Function
Lung Volumes and Capacities

**Volumes**
- Tidal Volume ($V_T$)
- Inspiratory Reserve Volume (IRV)
- Expiratory Reserve Volume (ERV)
- Residual Volume (RV)

**Capacities**
- Inspiratory Capacity (IC)
- Vital Capacity (VC)
- Functional Residual Capacity (FRC)
- Total Lung Capacity (TLC)
FIGURE 4-1. Normal lung volumes and capacities.

IRV = inspiratory reserve volume;
VT = tidal volume; RV = residual volume; ERV = expiratory reserve volume;
TLC = total lung capacity; VC = vital capacity; IC = inspiratory capacity;
FRC = functional residual capacity.
Assessment of Ventilation

Signs & Symptoms
Assessment of Ventilation

**Qualitative**

- Respiratory pattern
- Accessory muscle use
- Prolonged expiration
- Shortness of Breath (SOB)
- Cyanosis
- Minute ventilation ($VE = f \times V_T$)
Assessment of Ventilation

- **Quantitative**
- ABG’s (primarily CO₂)
- Pulse oximetry
- Capnography
- Transcutaneous monitoring
- NICO
1. Chemical Stimulants

- Oxygen and carbon dioxide influence rate and depth of respiration
- CO₂ is the primary stimulus

↑ CO₂ = ↑ rate and/or depth
↓ CO₂ = ↓ rate and/or depth
↓ O₂ = ↑ ventilation
↑ O₂ = ↓ ventilation
Quick Review

Respiration is the exchange of gases between the lungs and pulmonary blood vessels (external respiration) and between the blood and tissues (internal respiration). Oxygen and carbon dioxide move from one area to the other due to pressure gradients. Systemic levels of CO$_2$ and O$_2$, influence the depth and rate of ventilation with carbon dioxide acting as the primary stimulus for ventilation.
Assessment of Respiration

Arterial Blood Gas Variables

• **pH**
  This indicates the relative acidity or alkalinity of the blood. The normal range is 7.35 - 7.45. Values less than 7.35 are acid, and those above 7.45 alkaline.

• **PaCO₂**
  The partial pressure (tension) of carbon dioxide in the arterial blood. The normal range is 35 - 45 torr. Values less than 35 indicate excessive levels of ventilation, and values above 45 indicate a drop in ventilation.
Assessment of Respiration

Arterial Blood Gas Variables

- **PaO₂**: The partial pressure (tension) of oxygen in the arterial blood. The normal range, breathing room air, is 80 - 100 torr, values less than 70 indicate a lack of oxygen.

- **SaO₂**: This indicates the percentage of red blood cells that are combined with O₂. The normal range, breathing room air, is 90 - 100%. Levels below 90% indicate a lack of oxygen.
Gas pressures, or tensions, are usually expressed in units of torr. One torr is equal to one mm Hg (millimeter of mercury pressure), similar to what your local weatherman uses. Torr is used to honor Evangelista Torricelli who invented the mercury barometer. Torr and mm Hg can be used interchangeably, however torr is the preferred unit.
Ventilation-Perfusion Relationships

- Perfusion (Q)
- Ventilation (V)
- Need V/Q matching to achieve effective gas exchange.
- Normal V/Q ratio = 0.8
- Increased V/Q ventilation > perfusion (deadspace)
- Decreased V/Q perfusion > ventilation (shunt)
- Abnormal V/Q ratios alter work of breathing
The normal ventilation perfusion ratio (\( \dot{V}/\dot{Q} \) ratio) is about 0.8.
ALVEOLUS

\[ PAO_2 = 100 \text{ mm Hg} \]

\[ PACO_2 = 40 \text{ mm Hg} \]

NONOXYGENATED BLOOD

\[ PV_O_2 = 40 \text{ mm Hg} \]
\[ PV_{CO_2} = 46 \text{ mm Hg} \]

OXYGENATED BLOOD

\[ PAO_2 = 100 \text{ mm Hg} \]
\[ PACO_2 = 40 \text{ mm Hg} \]

BLOOD FLOW
Dead space ventilation ($V_D$)
Balance Between External Respiration and Internal Respiration (supply and demand)

- Exercise increases $O_2$ consumption and $CO_2$ production.
- If body cannot maintain balance to hypoxia and hypercarbia is reflected by clinical and laboratory assessment.
- Need adequate respiratory and cardiac function in order to maintain acid-base and supply-demand balance.
Quick Review

ABG’s are used to assess the effectiveness of respiration. Problems in external respiration occur from V/Q mismatches. Low V/Q areas produce oxygenation problems (shunting) and high V/Q ratios represent alveolar dead space ventilation. Internal respiration is the exchange of O₂ and CO₂ between the arterial blood and the tissues. Metabolic activity of the cells requires O₂ and produces CO₂ as a byproduct. ABGs are used to assess the level of O₂ available for metabolism and the effectiveness of lungs in removing CO₂.
Indications for Mechanical Ventilation

- Simply stated, mechanical ventilation is indicated when a patient is unable to adequately remove CO₂ and maintain adequate levels of O₂ in the arterial blood.
- Ventilation may be short or long-term depending on underlying disorder.
Goals of Mechanical Ventilation

- Decrease work of breathing
- Increase alveolar ventilation
- Maintain ABG values within normal range
- Improve distribution of inspired gases
Obstructive Lung Disease

Goal of Ventilation:
Reduce work of breathing

1. Emphysema

- Pathology: Destruction of terminal airways and air sacs.
- Concerns: Must assure adequate time and pressure for exhalation. Low pressures desirable to reduce the likelihood of damage to the lung, additional high airway resistance; end stages will also have poor lung compliance.
Obstructive Lung Disease

Goal of Ventilation:
Reduce work of breathing

2. Bronchitis

- Pathology: Chronic inflammation of mucous-producing cells. Hyper-reactive airways. Excessive abnormal secretions from irritation (infection, allergies, smoke, etc.).
- Concerns: Ventilation only supportive; must reduce volume of secretions and remove irritants.
Respiratory Dysfunction
Diagnosis confirmed via PFTs

**Obstructive Lung Disease**

- Decreased expiratory flowrates
- Increased RV, FRC, and TLC = air trapping “can’t get air out”
- Exhibit increased airway resistance
- Decreased elastance; increased compliance
- Examples: (COPD)
  a. asthma
  b. emphysema
  c. bronchitis
  d. bronchiolitis
Respiratory Dysfunction

Restrictive Lung Disease

- Decreased volumes and capacities, normal flowrates
- “can’t get volume in”
- Exhibit decreased compliance, increased elastance
- Examples:
  a. pulmonary fibrosis
  b. pulmonary edema
  c. pneumo/hemo thorax
  d. ARDS/IRDS
  e. chest wall deformities
  f. obesity
  g. neuromuscular disorders
Work of Breathing

Work = Force (pressure) x Distance (volume)

- Pressure generated must overcome:
  a. resistance of airways
  b. compliance of lung and chest wall
- Muscles of respiration are very inefficient
  - can fatigue and lead to respiratory failure
- Signs of fatigue:
  a. increased respiratory rate
  b. increased arterial CO$_2$
  c. paradoxical breathing
Mechanical Ventilation

1. **Negative Pressure Ventilators**
   - Iron lung
   - Cuirass

2. **Positive Pressure Ventilators**
   - Volume ventilators
   - Pressure ventilators
Negative Pressure Ventilation

- Creates a negative (subatmospheric) extrathoracic pressure to provide a pressure gradient.
- Mouth (atmospheric), Lungs (subatmospheric) = Inspiration
- Problems?

FIGURE 8-1  By applying subatmospheric pressure around the chest wall you can produce a drop in pressure in the airway and gas flow into the lungs.
Emerson Iron Lung
NEV 100 + Neumo suit
• Creates a positive intrapleural pressure in presence of atmospheric extrathoracic pressure.
• Mouth (atmospheric), Lungs (atmospheric) = Inspiration
• Problems?
Negative vs. Positive Pressure Ventilation

**FIGURE 8-1** By applying subatmospheric pressure around the chest wall you can produce a drop in pressure in the airway and gas flow into the lungs.

**FIGURE 8-2** Application of positive pressure at the airway provides a pressure gradient and therefore gas flows into the lungs.
Positive Pressure Ventilation

**Volume-Targeted Ventilation**

- Preset volume is delivered to patient.
- Inspiration ends once volume is delivered.
- Volume constant, pressure variable.
- Ensures proper amount of air is delivered to lungs regardless of lung condition.
- May generate undesirable (high) airway pressures.
Positive Pressure Ventilation

**Pressure-Targeted Ventilation**

- Preset inspiratory pressure is delivered to patient.
- Pressure constant, volume variable.
- Clinician determines ventilating pressures.
- Volumes may increase or decrease in response to changing lung conditions.
(TRIGGERING) Starting Inspiration

1. Manual Trigger
2. Patient (Flow/Pressure)Trigger - (assist)
3. Time-Trigger- (control)
4. Patient/Time-Trigger (assist/control)
(CYCLING) Ending Expiration

1. Pressure
2. Volume
3. Time
4. Flow
5. Manual
Ventilator Parameters

Settings
**Volume-Targeted Ventilation**

**Tidal Volume**

- **Definition:** How much air movement is needed to adequately remove CO₂ from the blood.

- **Setting:** Usually 8-10mL/kg or adjusted as indicated by arterial CO₂ levels.
Respiratory Rate

- **Definition:** The frequency that the tidal volume must be delivered to adequately remove CO₂.
- **Setting:** Usually 12-14/min may be increased or decreased as indicated by arterial CO₂ levels.
Peak Inspiratory Pressure

- **Definition:** Reflects airway resistance and lung compliance (work required to move air through the airways and into the alveoli).

Elevated with either increased resistance (tracheal tube, ventilator circuitry) or decreased compliance.
**Inspiratory Time**

- **Definition:** Part of the ventilatory cycle necessary for inspiration
- **Setting:** Maintain an I:E of 1:2 or greater (1:3, 1:4, etc.)
Pressure-Targeted Ventilation

**Peak Inspiratory Pressure**

- **Definition:** Reflects airway resistance and/or lung compliance.
- **Setting:** Set to allow the delivery of an adequate tidal volume.
Modes of Ventilation
Control

- Indicated when patient cannot initiate inspiration.
- Inspiration is initiated by timing device.
- Machine controlled breath.

Control Mode (Pressure-Targeted Ventilation)

Click on the graphic to see details

Back to Index
Control Mode
(Pressure-Targeted Ventilation)

Flow (L/min)
Pressure (cm H₂O)
Volume (ml)
Time (sec)

• Breath initiated by patient unless rate falls below selected respiratory rate.
• Each breath’s pressure or volume is preset.

Click on the graphics to see details
Patient Triggered, Pressure Limited, Time Cycled Ventilation

Flow (L/min)

Pressure (cm H2O)

Volume (ml)

Time (sec)

Set PC level

Time-Cycled

Assist-Control Mode
(Volume-Targeted Ventilation)

Patient triggered, Flow limited, Volume cycled Ventilation

Flow-Trak™
VCV made easy!
What Is Flow-Trak

• It’s an enhancement to standard VCV

• Doesn’t punish the patient if Peak Flow setting is inappropriately low

• If the peak flow or tidal volume does not meet the patient’s demand, Flow-Trak will give additional flow to satisfy patient need
<table>
<thead>
<tr>
<th>Features</th>
<th>Benefits</th>
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</thead>
<tbody>
<tr>
<td>It’s always on</td>
<td>Easy to use</td>
</tr>
<tr>
<td>No additional settings</td>
<td>Enhances patient-to-ventilator synchrony</td>
</tr>
<tr>
<td>Allows unrestricted access to flow/volume within a VCV breath without increasing driving pressure</td>
<td></td>
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<tr>
<td>Maintains the same expiratory time</td>
<td>Reduces the likelihood of breath-stacking and Auto-PEEP</td>
</tr>
<tr>
<td>Features</td>
<td>Benefits</td>
</tr>
<tr>
<td>----------------------------------------------</td>
<td>--------------------------------------------------------------</td>
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<tr>
<td>High Ve alarm</td>
<td>Alerts clinician to consistent increased ventilatory demands</td>
</tr>
<tr>
<td>Switches back to VCV if initial flow demand decreases before set Vt is delivered</td>
<td>Ensures the preset Vt is always delivered</td>
</tr>
<tr>
<td>Patient controls insp time on Flow-Trak breaths</td>
<td>Patient-to ventilator synchrony</td>
</tr>
</tbody>
</table>
Flow-Trak – Simple Version

- **Inspiration**
  - Starts off as standard VCV breath either with square or decelerating flow pattern
  - If circuit pressure drops to PEEP minus 2cm H$_2$O (patient outdraws set flow), Flow-Trak is initiated.

- Once Flow-Trak is triggered it will pressure control to a target of 2 cmH$_2$O above baseline.
Without FlowTrak

Concave Pressure Curve

Pressure cmH2O

Profound Patient-to-ventilator dysynchrony ensues
Without FlowTrak

Pressure
cmH₂O

Flow
LPM

Breath Triggered
Intermittent Mandatory Ventilation (IMV)

- Machine delivers a set number of machine breaths, patient can breathe spontaneously between machine breaths.

Synchronized Intermittent Mandatory Ventilation (IMV)

- Patient-initiated breath.
- Prevents breath stacking.
SIMV+PS
(Volume-Targeted Ventilation)

Continuous Positive Airway Pressure (CPAP)

- Preset pressure is maintained in the airway.
- Patient must breathe spontaneously - no mechanical breaths delivered.
- “breathing at an elevated baseline”
- Increases lung volumes, improves oxygenation.

Click on the graphic to see details.
CPAP

Flow (L/min)

Pressure (cm H₂O)

Volume (ml)

Time (sec)

Pressure Support Ventilation (PSV)

- Patient-triggered, pressure-limited, flow-cycled breath.
- Augments spontaneous ventilation.
- Commonly used as a weaning mode.
- Pressure plateaus at set pressure until inspiration ends (flow).
PSV

Patient Triggered, Flow Cycled, Pressure limited Mode

Pressure Control Ventilation

• Mechanical breath delivered at a preset peak inspiratory pressure.
• Can be used with inverse ratios.
• Mode of choice in management of patients with ARDS.
Airway Pressure Release Ventilation (APRV)

- Similar to CPAP, except at a predetermined time, system pressure will drop to a lower CPAP level or ambient pressure.
- Aids in CO₂ removal.
- Drop is short in duration.
- Allows patient to breathe spontaneously at two levels of CPAP.
Bi-Level Positive Airway Pressure (BiPAP)

- Non-invasive ventilation.
- Set IPAP to obtain level of pressure support.
  - Improve ventilation.
- Set EPAP to obtain level of CPAP.
  - Improve oxygenation.
High Frequency Ventilation

- Small tidal volumes < deadspace breaths at high rates.
- Different modalities:
  - High Frequency Jet Ventilation
  - High Frequency Flow Interruption
  - High Frequency Positive Pressure Ventilation
  - High Frequency Oscillatory Ventilation

Back to Index
Ventilator Controls
Ventilator Controls

1. Mode

2. Tidal Volume (volume ventilator)
   - 6-10 mL/Kg ideal body weight
   - measured at ventilator outlet

3. Respiratory Rate
   - normally 12-15 bpm
   - alters E time, I:E ratio, CO₂
4. Flowrate
   - normal setting is 40-60 Lpm
   - alters inspiratory time

5. I: E ratio
   - normal is 1: 2 (adult); 1: 1 (infant)
   - volume, flowrate, and rate control alter I:E ratio

6. FiO2
   - Titrate to keep SpO₂ > 90%
Ventilator Controls

7. Sensitivity
   - normally -0.5 to -2 cmH20

8. Inflation hold
   - used to improve oxygenation, calculate static compliance

9. PEEP
   - used to increase FRC - improve oxygenation

10. Alarms
Ventilatory Management
Mechanical Ventilation

- Establish ARF
- Appropriate Initial Settings
- Weaning & Extubation
- Appropriate Alarm Settings
- Titrating Parameters
- Monitoring
Mechanical Ventilation

- Pressure
- Volume
- Parameter Titration
- Noninvasive Assessment
- Other Ventilator Parameters
- Acidbase Balance & Oxygenation
Modes of Ventilation

- **Spontaneous**
  - Spontaneous
  - CPAP
  - PSV

- **Assist**
  - Assist
  - SIMV + CPAP
  - SIMV + PSV

- **Assist/control**
  - SIMV
  - SIMV + PSV
  - CPAP + PSV + CPAP

- **Control**

- **FULL SUPPORT**
  - Control
  - Assist
  - Assist/control

- **SPONTANEOUS**

- **PARTIAL SUPPORT**

- **CPAP**

- **PSV**
\[ \dot{V}_A = \dot{V}_E - \dot{V}_D = (V_T - V_D) f \]
Titration of Parameters

VE and PaCO₂

Tidal Volume ($V_T$) x Frequency (f)

$V_E$  PaCO₂
Tidal Volume (VT) x Frequency (f)
Titration of Parameters

\[ \text{VE} \quad \text{and} \quad \text{PaCO}_2 \]

- Tidal Volume (\(V_T\))
- Frequency (\(f\))
Titration of Parameters

$\text{Tidal Volume (V}_T\text{)} \times \text{Frequency (f)}$

$\text{f}$

$\text{PaCO}_2$
Titration of Parameters $f$ and $\text{PaCO}_2$

Tidal Volume ($V_T$) x Frequency ($f$)
Parameter Titration
PaO₂ and FiO₂

Increased FiO₂ increases PaO₂

Decreased FiO₂ decreases PaO₂
Capnography

- EtCO$_2$
- Capnogram
- Respiratory Rate

Volumetric CO$_2$

- CO$_2$ Elimination
- Deadspace
- Alveolar Ventilation
- Physiologic Vd/Vt
The integration of $CO_2$ and Flow provides an easy method to obtain previously difficult to obtain parameters

- $VCO_2 = CO_2$ Elimination
- Airway Deadspace, Physiologic $V_D/V_T$
- Alveolar Ventilation
- Cardiac Output

<table>
<thead>
<tr>
<th>Capnography</th>
<th>Volumetric CO$_2$</th>
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<tr>
<td>• EtCO$_2$</td>
<td>• CO$_2$ Elimination</td>
</tr>
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<td></td>
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</tr>
</tbody>
</table>
CO$_2$ Metabolism

- Muscle
- Circulation
- Ventilation

Muscle: CO$_2$, O$_2$
Circulation: CO$_2$, O$_2$
Ventilation: CO$_2$, O$_2$

VO$_2$, VCO$_2$
Metabolism (CO₂ Production)

CO₂ Elimination (VCO₂)

PaCO₂

Things that affect CO₂ elimination

1. Metabolism (CO₂ Production)

2. PaCO₂

VCO₂ - A Few Basics

Circulation

Diffusion

Ventilation
CO$_2$ Elimination (VCO$_2$)

**Why Measure VCO$_2$?**

- Very Sensitive Indicator of PATIENT STATUS CHANGE
- Signals Future Changes in PaCO$_2$
- Defines When to Draw a Blood Gas ➔ Reduces the # of ABGs

**VCO$_2$ - A Few Basics**

1. Why Measure VCO$_2$?
2. CO$_2$ Elimination (VCO$_2$)
3. Reduces the # of ABGs
Why Measure VCO₂?

- Very Sensitive Indicator of PATIENT STATUS CHANGE
- Signals Future Changes in PaCO₂
- Defines When to Draw a Blood Gas ➔ Reduces the # of ABGs
HMM!! VC02?

Oxygen  \[\text{CO} = 5.0\]  Pulmonary Blood Flow

VC02
Open Lungs

[Images of lung inflation and deflation at different pressures]

[Graph showing pressure-volume relationship]
Oleic Acid In Dog

If Graphics are the Headlights on the Ventilator,

Then RUNNING NICO,

is Turning on the HIGH BEAMS!!!
Principles and Application of NPPV
Performa Trak SE

For use with critical care ventilators with dual limb circuits and internal safety valves
Auto-Trak Sensitivity
This is what we do.

NIPPV: Non Invasive Positive Pressure Ventilation
NIPPV: Patient Selection Criteria

- Chronic Respiratory Failure
- Acute Respiratory Failure
- Stable Hypercapnic COPD
- Respiratory Failure Progressive Neuromuscular Disease
- Cystic Fibrosis
- Mixed Sleep Apnea/Hypoventilation
- Lung Transplant Candidates
- Chest-Wall Deformity
- Ventilatory muscle fatigue / dysfunction...

When?
NIPPV Goal 1:

Mechanisms for Improvement

- Resting the respiratory muscles
- Increasing in Lung Compliance
- Resetting Central Chemoreceptors

Augment patient’s ability to breathe on a spontaneous basis

$CO_2$ sensitivity is blunted during failure
NIPPV Goal 2: For the patient

- Improve patient comfort
- Avoid significant risk of nosocomial infection
- Maintain airway defense, speech, swallowing
- Avoid complication of ET-Intubation
- Reduce needs for sedation
- Cuff ulceration, oedema, haemorrhage
- Injury to the pharynx, larynx, trachea

For the Patient
NIPPV: Clinical effect

- Improve Alveolar Minute Ventilation
- Correct Gas Exchange Abnormalities
- Augment spontaneous breathing
- Decrease Work of Breathing
- Improve quality of sleep
- Improve quality of life

Main concern

Improve quality of life
Mechanisms for improvement

For the patient

Clinical effect

Source: Kramer, Clinical Pulmonary Medicine 1996; 3: 336-342
General Overview NIV Pneumatic Design

Air Filter
Ambient Air
Blower

Patient Circuit
AFM (mass airflow sensor)
Exhaust
PVA (pressure valve assy)

Air Filter
Ambient Air
**Respironics is the inventor of the BiPAP® Systems**

**The Concept**

Two pressure levels:

- PS = IPAP - EPAP
- PEEP = EPAP

Pressure Support with PEEP (Especially suited for Non Invasive Ventilation)

Continuous flow circuit

**Our Know How**

- Detects and learns leaks
  - To maintain automatic trigger sensibility
  - Optimise performance
BECAUSE:
It is virtually impossible for preset sensitivity settings to keep pace with:

- Wide variation in breath to breath effort
- Constantly changing breathing patterns
- Ventilation difference between Night & Day
- Of unpredictable leaks
- Ongoing circuit leaks
To meet the demands of NIV problems

The solution by RESPIRONICS is Auto-Trak Sensitivity™
Two main topics of the Auto-Trak Sensitivity™

• 1 - Leak tolerance  Automatically adjusts sensitivity to changing breathing patterns and leak conditions
  - Tidal Volume adjustment
  - Expiratory flow rate adjustment

• 2 - Sensitivity
  - Variable Trigger Thresholds  (EPAP to IPap)
  - Variable Cycle Thresholds  (IPAP to EPap)
Leak Ventilation $\Rightarrow$ Flow Analysis

Total Flow = Estimated Patient Flow + Estimated Leak Flow

$V_{\text{tot}} = V_{\text{est}} + V_{\text{leak}}$
From EPAP to IPAP and IPAP to EPAP: Definitions

Variable **Cycle** Threshold

Variable **Trigger** Threshold

FLOW

PRESSURE Cm H2O
Adjustment of \( V_{\text{leak}} \) for the next breath

- \( V_{\text{Inspiration}} = V_{\text{Expiration}} \) (No change in baseline)
- \( V_{\text{Inspiration}} > V_{\text{Expiration}} \) (New Baseline)
- \( V_{\text{Inspiration}} < V_{\text{Expiration}} \) (New Baseline)

Adjustment of \( V_{\text{leak}} \) for the next breath
Cycle Variables

SET (Spontaneous Expiratory Threshold)

Benefit:
Detects gradual changes in patient flow from prolonged exhalation periods.
Main results from the Auto-Trak Sensitivity™ associated with our BiPAP technology

Synchronise Pressure to Patient Flow

Adjust Sensitivity Threshold

Greater Patient Comfort

Decreasing Work of Breathing

Exceptional Pressure Stability

BEST PATIENT COMPLIANCE
The Best compliance for the Best ventilation from Acute to Home Care.
RESPIRONICS Product where our Auto-Trak Sensitivity™ technology is integrated:

- Duet Lx
- BiPAP® ST30, ST/D30
- Harmony™
- Focus
- Vision™
PUBLIC NOTICE !!

How would you know if your cow suffers from Mad Cow Disease?

If your cow sounds like this... Prepare the grill!

If your cow sounds like this... You better buy some fish or chicken!