Taking NIV Further
NIV - Goals for Use

• Avoid intubation
• Increase PaO₂
• Decrease PaCO₂
• Alleviate dyspnea
• Decrease WOB
  – Not to impose extra WOB due to the presence of changing leaks
• Unloading the respiratory muscles allowing them to rest
• Increase alveolar ventilation
Hypercarbic ARF
Hypoxemic ARF
Indications

• “When feasible and not medically contraindicated, use noninvasive positive-pressure ventilation delivered continuously by face or nose mask, instead of performing endotracheal intubation in patients who are in respiratory failure and are not needing immediate intubation.”

• “When feasible and not medically contraindicated, use NIV as part of the weaning process…”

CDC 2004 Guidelines for Preventing Health-Care Associated Pneumonia

CDC MMWR Mar 2004; 53: RR-3
Patient Selection Considerations in Acute Applications

• **Strong evidence**
  - CHF
  - COPD exacerbation
  - Facilitating weaning of COPD
  - Immunocompromised patients

• **Weak evidence**
  - Partial UAW obstruction
  - ARDS
  - Trauma

• **Moderately strong evidence**
  - Asthma
  - Cystic Fibrosis
  - Postoperative RF
  - Avoidance of extubation failure
  - DNI patients

Strong = multiple controlled trials
Moderately strong = single controlled trial or multiple case series
Weak = a few case series or case reports

Acute Applications of Noninvasive Positive Pressure Ventilation; T. Liesching, H. Kwok, N. Hill; Chest 2003;124:699-713
Physiologic criteria for NIV consideration

- Moderate to severe respiratory distress
- Tachypnea (RR > 24 BPM)
- Use of accessory muscle or paradoxical abdominal breathing
- Gas exchange
  - pH < 7.35
  - PaCO₂ > 45 mm Hg
  - PaO₂:FiO₂ < 200 mm Hg
NIV – Contraindications

- Patient is not breathing spontaneously
- Patient’s airway is compromised
- Cardiovascular problems
- Patient is unable to clear secretions
- No improvement on NIV in first two hours of implementation
- Unable to adapt a mask interface
- Uncooperative patient
IPAP

• Adjust IPAP to Establish Pressure Support
• PS = IPAP – EPAP
• Augment Ventilation
  – Increase tidal volume
  – Decrease CO2
• Relieve dyspnea
• Rest respiratory muscles
  – Reduce work of breathing
EPAP

- EPAP = PEEP
- Increase FRC
  - Improve oxygenation
  - Reduce work associated with Auto PEEP
  - Stabilize upper airway (OSA)
BiPAP

Pressure Support

IPAP

EPAP

Pressure
Changes In EPAP Pressure

Decreasing Delta pressure will usually result in lower Vt
Taking NIV further

The Respironics V60 Ventilator gives you the confidence to treat a wider range of patients
V60 NIV Modes

- ST
- AVAPS
- CPAP with C-Flex
What is S/T (Spontaneous Timed)?

- In S/T ventilation, a set IPAP pressure and a set EPAP pressure is delivered to the patient
  - The patient controls the inspiratory time
  - In the S/T mode, a timed breath is only delivered if the patient rate drops below the set backup rate.
  - A mandatory breath is only delivered at a set I-Time when the patient doesn’t meet the rate.
Pressure Support Ventilation – S/T

- Patient or machine triggered
- Flow cycled if spontaneous breath
- Time cycled if machine triggered breath
- TV is variable depending:
  - Pressure support level
  - Inspiratory time

**Pressure Support Ventilation (PSV)**
Inspiratory Time depends on patient breathing pattern

$T_1 \neq T_2$
ST Pressure Waveform

- **Pressure**
  - IPAP (Inspiratory Positive Airway Pressure)
  - EPAP (Expiratory Positive Airway Pressure)

- **Time**
  - **Rise**
  - **Mandatory (Timed) breath**
  - Patient-triggered (Spont) spontaneous breath with pressure support

- **Parameters**
  - 1/Rate
  - I-Time
Average Volume Assured Pressure Support

AVAPS

New Mode: AVAPS

- VT: 500 mL
- Rate: 4 BPM
- I-Time: 1.00 secs
- Rise: 3
- EPAP: 4 cmH2O
- Min P: 10 cmH2O
- Max P: 25 cmH2O
- O2: 21%

Activate AVAPS Mode

Cancel

S/T Settings | Alarm Settings | Modes | Menu | Standby
AVAPS

• What is AVAPS
  – Average volume-assured pressure support
  – Vent automatically modifies pressure to maintain an average target user-defined VT
    • 1 cmH₂O to possibly 2.5 cmH₂O per minute change in pressure per minute
  – During AVAPS setup, there may be a period of time before the target tidal volume is achieved
  – AVAPS **should not** be used when rapid IPAP adjustments are needed to achieve the desired VT
AVAPS

• This mode is not a PRVC type mode
  –It will **not** respond quickly
• Not intended for patients with **high resistance and low compliance**
  –Patients should be through their acute phase
• It is ideal for stabilized chronic patients
• **Do not use a nasal mask when in the AVAPS mode**
AVAPS - Setup

• AVAPS-specific settings: target VT, Min P, and Max P

Set:
• Target Vt
• Min P (which is the minimum IPAP pressure)
• Max P (maximum IPAP pressure).

The best way: observe the set EPAP/IPAP and Vt readings on S/T mode.
Set Min P at what IPAP value was on S/T.
Set Max P above Min P so that the patient will be able to achieve an increased flow/pressure when needed.

If calculated target pressure is outside Min P or Max P range, the target tidal volume will not be achieved.
Principles of Operation

- Max P
- Min P
- EPAP
- Mandatory (Timed) breath
- Rise
- 1/Rate
- I-Time
- Patient-triggered (Spont) spontaneous breath
- Flow
- $V_T$
- Volume
- Time
Average volume-assured pressure support

AVAPS automatically adapts pressure support (< 2.5 cmH\textsubscript{2}O) per minute to guarantee an average tidal volume.
AVAPS alarm

• If target VT is not achieved due to insufficient Max P
  – Information message will appear
  – **You have to set a Low VT alarm in order to have an audible alert**
• Low VT delayed for 2 minutes after activation of AVAPS
AVAPS alarms

• If target VT is exceeded due to Min P set too high
  – Information message will appear
  – You have to set a high VT alarm to have an audible alert
EPAP relative to Min P

EPAP is limited to values less than Min P – 1 cmH₂O

In this example Min P must be ↑ before EPAP can be ↑
• Neuromuscular disorders
  – With standard bi-level therapy, a patient’s tidal volume declines as disease process worsens
• Restrictive thoracic disorder
  – Chest wall deformities (e.g. kyphoscoliosis)
  – Slow progressive disease
• Obesity hypo-ventilation syndrome
  – A change in body position increases airway resistance
  – Without an increase in pressure support, VT declines
• In short, any chronic disease process that is past the acute phase (e.g. COPD, CHF)
CPAP with C-flex
CPAP (Continuous Positive Airway Pressure)

$CPAP = 5 \text{ cmH}_2\text{O}$
C-Flex

Active Mode: CPAP

CPAP: 6 cmH2O
Ramp: OFF
C-Flex: 2
O2: 21%
What is C-Flex?

- C-Flex is an option on the V60
  - Only available in CPAP Mode
- C-Flex enhances traditional CPAP by reducing the pressure at the beginning of exhalation
  - This is when patients are often uncomfortable with CPAP
  - C-Flex returns to the set CPAP pressure before the end of exhalation
- Should not be used in patients requiring CPAP for oxygenation purposes
C-Flex

• The amount of pressure relief is determined by the C-Flex setting and the expiratory flow of the patient
  – The higher the setting number (1, 2 or 3)
  – And the greater the expiratory flow
  – The greater the pressure relief
    ○ During the active part of exhalation only
C-Flex

Reduces pressure at the beginning of exhalation and returns to therapeutic pressure just before inhalation

Pressure relief varies on flow and C-Flex setting
Longitudinal comparison study of pressure relief (C-Flex™) vs. CPAP in OSA patients

Diana C. Dolan • Renata Okonkwo • Florian Gfullner • J. Randall Hansbrough • Richard J. Strobel • Leon Rosenholz

![Graph showing VAS scores for Mask Comfort, Treatment Comfort, and Treatment Satisfaction for CPAP and C-Flex](image)

**Fig. 2** Comparison of the ratings on the VAS scores by treatment. Possible scores range from 0 to 100. There was a main effect of mask comfort ($p = .01$)
Randomised trial of compliance with flexible (C-Flex) and standard continuous positive airway pressure for severe obstructive sleep apnea

Nathaniel S. Marshall • Alister M. Neill • Angela J. Campbell

This randomised trial provides some evidence that C-Flex might increase initial treatment compliance, compared to CPAP, in patients with severe OSA. However, this trend toward greater compliance was not associated with better short-term treatment outcomes for patients. These findings need to be confirmed in a larger, longer-term trial.
Efficacy and patient satisfaction with autoadjusting CPAP with variable expiratory pressure vs standard CPAP: a two-night randomized crossover trial

A. T. Mulgrew • R. Cheema • J. Fleetham • C. F. Ryan • N. T. Ayas

C-Flex eliminates sleep disordered breathing as effectively as standard CPAP. Patients indicated a preference for APAP with C-Flex suggesting a possible advantage in terms of patient adherence for this mode of treatment.
Treatment Adherence and Outcomes in Flexible vs Standard Continuous Positive Airway Pressure Therapy*

Mark S. Aloia, PhD; Michael Stanchina, MD; J. Todd Arnedt, PhD; Atul Malhotra, MD, FCCP; and Richard P. Millman, MD, FCCP

Conclusions: Therapy with the C-Flex device may improve overall adherence over 3 months compared to standard therapy with CPAP. Clinical outcomes do not improve consistently, but C-Flex users may be more confident about their ability to adhere to treatment. Randomized clinical trials are needed to replicate these findings. *(CHEST 2005; 127:2085–2093)*
C-Flex: Potential new indications

• Acute settings
  – Acute respiratory failure in OSAS
  – Acute respiratory failure in OHS
• Chronic settings
  – OSAS to improve tolerance and use
• Should not be used in patients requiring CPAP for oxygenation purposes

Just remember – it’s CPAP!
Keys to success

The ideal NIV therapy experience

• Trained staff
• Appropriate mask selection
• Patient-to-ventilator synchrony
  – Optimum mask and ventilator performance
  – System compatibility
• Patient compliance
• Patient coaching and earning trust
• Wound Care Nurse, Nurse, RT
• Mask Fitting workshops
Patient Selection

1. FAVORABLE DIAGNOSES
   - Strong Evidence
     - COPD exacerbation
     - Acute pulmonary edema / CHF
     - Immunocompromised patients
     - Facilitate weaning of COPD patients
   - Intermediate Evidence
     - Asthma
     - Community-acquired pneumonia in COPD patients
     - COPD & CHF patients with DNR/DNI status
     - Post-operative respiratory failure
       (lung resection, bariatric, CABG)
   - Weaker Evidence (CAUTION)
     - ARDS with single-organ involvement
     - Community-acquired pneumonia
       (non-COPD patients)
     - Cystic fibrosis
     - Neuromuscular disease/coordination
     - OSA/obesity hypoventilation
     - Upper airway obstruction

2. UNFAVORABLE DIAGNOSES
   - End-stage pulmonary fibrosis
   - Severe ARDS (multi-organ failure)
   - Upper-airway or esophageal surgery
   - Upper-airway obstruction with high risk for obstruction
   - CONTRAINDICATED
     - Cardiorespiratory arrest
     - Medically unstable
       (hypotensive shock, uncontrolled
cardiovascular ischemia or arrhythmia)
     - Unable to protect airway
       (impaired cough or swallowing)
     - Excessive secretions
     - Facial surgery, tracheal, burn, or
defect preventing mask fit
     - Severe UGI bleeding
     - Agitated or uncooperative
     - Untreated pneumothorax
     - Multi-organ system failure

If unfavorable diagnosis or a contra-
indication is present, consider intubation.

3. SIGNS AND SYMPTOMS
   - If a spontaneously breathing patient
     with moderate to severe respiratory
distress presents with one or more
   of the following consider NIV:
     - Accessory muscle use
     - Paradoxical breathing
     - VR > 24 (hypercapnic)
     - VR > 38 (hypoxemic)
   - If not, consider other therapy

4. GAS EXCHANGE CRITERIA
   - If patient falls within the criteria below,
     initiate NIV do not await ABG results in
     severely dyspneic patient:
     - PaCO₂ > 45 mm Hg (hypercapnic)
     - pH 7.19 – 7.35
     - Hypoxemic respiratory failure with
       PaO₂/FiO₂ < 300
   - If acuity increases, consider intubation
     especially if SAPS II > 34 or P/F < 100
1. CHOOSE VENTILATOR
   - Bilevel noninvasive ventilator
   - Invasive ventilator in PSV mode or NN mode

2. CHOOSE AND FIT APPROPRIATE INTERFACE
   - Full face mask (1st choice for initiation)
   - Nasal mask if full face mask not tolerated
   - Total face mask
   - Other

3. INITIAL SETTINGS
   - In S/T mode, set IAP/EPAP = 8-12/4-6
   - In PSV mode, set PSV/PEEP = 4-9/4-5
   - Set back-up rate = 12 if rate cannot be set on ventilator

4. CHOOSE PROPER LOCATION
   - Transfer patient to ICU or step down unit, white acutely ill
   - Consider Adjuncts
     - Humidification if > 2-3 hrs.
     - Insert nasogastric tube only if high risk of aspiration or vomiting
Adaptation

1. Titrate pressures to meet ventilation needs

2. Adjust IPAP or PSV if:
   - Persistent RR > 30, elevation of PaCO₂, respiratory distress or excessive use of neck muscles
   - Increase IPAP by 2-5 cm H₂O q 5-15 minutes as tolerated
   - If intolerant, check for air leak and/or poor mask fit (a small leak is OK)
   - If patient is still intolerant of increased pressure, consider lowering inspiratory pressure

   Optimize Patient-Ventilator Synchrony
   - Coach breathing with the ventilator
   - Minimize air leaks
   - Optimize rise time (if available)
   - Increase EPAP if auto-PEEP
   - If synchrony remains poor, consider conscious sedation
   - If delayed cycling, limit inspiratory time

3. Adjust EPAP or PEEP (and IPAP or PSV)
   - If: Inadequate oxygenation
     - Significant auto-PEEP
   - Then:
     - Increase EPAP by 1-2 cm H₂O q 5 minutes, watching FiO₂/effort
     - Titrate FiO₂ or oxygen flow to maintain SpO₂ > 90%
     - May lower EPAP if intolerant but not < 4 cm H₂O

   Note: When increasing EPAP, increase IPAP by same amount to maintain same level of pressure support (for uncompensated PEEP ventilation)

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**MONITOR & DOCUMENT**
- Patient comfort and tolerance
- Vital signs, especially respiratory rate
- Neck muscle activity
- Interface fit and air leakage
- Patient/ventilator synchrony
- Trial volume (6-7 ml/Kg)
- Continuous pulse oximetry
- ABG at baseline, after 1-2 hours and then as needed

**PREDICTORS OF SUCCESS**
- Lower SAPS II / APACHE II score
- Willing and able to cooperate
- Good mask fit
- RR < 36/min, decreased WOS
- Improvements in gas exchange, pH, HR, RR in the first 2 hours

**IF NO IMPROVEMENT AFTER 2-3 HOURS, STRONGLY CONSIDER USE OF INVASIVE MECHANICAL VENTILATION.**

(Continued)
**Weaning**

1. **CONTINUE MONITORING**
   - Frequently reassess alarms and ventilator settings.
   - Assess if patient meets weaning guidelines, including clinical stability, adequate response of underlying disease. RR < 24, HR < 10 b/min, compensated pH > 7.35, O2 sat ≥ 90% on ≤ 50% FiO2 or 6 L/min O2.

2. **WEANING**
   - Attempt trial off NIV with O2 adjusted for rate ≤ 50%. Monitor oxygen saturation and gradually extend weaning periods as tolerated.
   - Resume use of NIV if initiation criteria return.
   - Gradually titrate IPAP or PSV, downward by 2-3 cm H2O as tolerated.

3. **CONTINUE OR D/C NIV**
   - Does patient demonstrate clinical evidence of respiratory distress?
   - Yes: Restart NIV at previous settings.
   - No: Discontinue NIV.