New Tools of the Trade for Implementing a Successful NIV Program

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Course Objectives

• Review indications and complications of NIV
• Define NIV Goals and Success
• Review Auto-Trak Sensitivity
• Define Hospital-Acquired Pressure Ulcers (HAPU), risk factors, etiology, prevention, treatment, and implications
• Discuss new NIV modes and features: AVAPs, PPV, Auto-Trak +, and C-Flex
Patient selection considerations

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

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

• **Weaker evidence**
  - Partial UAW
  - ARDS
  - Trauma

Strong = multiple controlled trials
Moderately strong = single controlled trial or multiple case series
Weaker = 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
NIV Success

- Success of NIV is usually defined as avoidance of intubation
- Many factors may influence the success rate
- What is an acceptable or desirable success rate?
MGH, acute respiratory failure

NPPV Outcomes

Schettino, et al; Crit Care Med,36(2):441-447
Goals of NIV

• Alleviate respiratory distress by
  – Improving gas exchange\textsuperscript{1,2}
  – Reducing work of breathing\textsuperscript{1,2}
    ▪ Decrease rapid shallow breathing
  – Augmenting alveolar ventilation

• Achieve patient-to-ventilator synchrony\textsuperscript{3}

• Minimize risks and avoid complications associated with endotracheal intubation\textsuperscript{1,2}

\textsuperscript{1}Hill, N. Non-invasive ventilation for chronic obstructive pulmonary edema., \textit{Resfor Care} 2004 ;49(1):72-87.
\textsuperscript{3}Sniuff, T. Clinical Practice Guideline for the Use of Noninvasive Positive Pressure Ventilation in COPD Patients With Acute Respiratory Failure. Journal of Critical Care, Vol 19, No 2 (June), 2004: pp 82-91
NIV Utilization and Success

• “There is arguably more evidence to support the use of NIV than any other practice related to the care of patients with acute respiratory failure. Despite this strong evidence base, NIV seems to be under-utilized”

• Hess, DR. Respir Care 2011;56(2):153:165
NIV Utilization

• It is estimated that 25-30% of all mechanical ventilation in North America is delivered via Non-Invasive techniques
  – The utilization in Europe is closer to 50%
• Why the disparity???
• **Conclusions:** The utilization rates for NPPV vary enormously among different acute care hospitals within the same region. The perceived reasons for lower utilization rates include lack of physician knowledge, insufficient respiratory therapist training, and inadequate equipment. Educational programs directed at individual institutions may be useful to enhance utilization rates.
RT Directors Reasons for Low NIV Utilization

Maheshwari et al, Chest 2006
Clinical keys to success

- Early intervention
  - Consider NIV as the first mode of ventilator support
  - The earlier the initiation, the higher the success rate
  - Availability of equipment and staff
- Trained staff
- Appropriate interface
- High performance equipment
- Cardiopulmonary monitoring
RT Time to Initiate and Provide NIV

Kramer et al, Am J Respir Crit Care Med 1995
Ventilator selection

- Type
  - Critical care
  - Noninvasive (bilevel)
  - CPAP
- Leak Compensation
- Oxygen delivery capability
  - 21-100%
- Integrated alarms

Respir Care 2004; 48(10):919-921
Why use a BiPAP Ventilator for NIV?

• Performance capabilities
  – Automated Leak compensation
  – Optimal triggering and cycling
  – Flow and Pressure specs
  – Rise time adjustment
• Comprehensive monitoring
  – Waveforms
  – Patient data

Respiratory Care; 48(10):919-921
Digital Auto-Trak™ Sensitivity

- Leak tolerance and compensation
- Optimal triggering and cycling
- Continuously automated adjustment and response to changes in patient demand
Enhanced Leak Compensation

• Digital Auto-Trak™ Sensitivity provides up to 60 L/min of Leak compensation
• Provides breath-to-breath, automated adjustment to insure stable pressure delivery
• Eliminates the need for an air-tight mask seal
• Insures accurate monitoring of Tidal Volume
Shape Signal concept

Benefit: Detects rapid change in patient flow
Auto-Trak Sensitivity™ - Breath cycling

• Provides automatic and continuous adjustment of breath termination threshold
  – Optimal patient-ventilator synchrony
  – Improved patient comfort
  – Eliminates the need for “active exhalation”
Shape Signal concept

**Cycle** to EPAP Crossover Point

**Benefit**: Detects rapid change in patient flow
Interface selection

- Estimate length of use
- Compatibility with device
- Safety features
- Facial features
  - Skin condition
  - Facial abnormalities
- Up to 50% of NIV failures are related to the interface
Interface Considerations

• Interface types
  – Total face mask
  – Full face mask
  – Nasal mask

• Headgear selection
Interface Design Features

• Ease of application
• Stability and adjustable headstrap for custom fit
• Soft, self-sealing, comfortable cushion
• Adequate seal with minimal pressure applied to face and nose
• Safety features
• Ability to maintain a “prescription” leak
Clinicians remove interfaces an average of 18-20 times per DAY!
## Interface related complications of NIV

<table>
<thead>
<tr>
<th>Adverse Effect</th>
<th>Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discomfort</td>
<td>Check fit, adjust straps, change interface</td>
</tr>
<tr>
<td>Excessive air leaks</td>
<td>Realign interface, check strap tension, change to full face mask</td>
</tr>
<tr>
<td>Nasal bridge redness or ulceration</td>
<td>Use artificial skin, minimize strap tension, use spacer, alternate interface or use a PerforMax or Total face mask</td>
</tr>
<tr>
<td>Skin irritation or rashes</td>
<td>Use skin barrier lotion and/or topical corticosteroids, change to mask made from a different material, properly clean mask</td>
</tr>
<tr>
<td>Claustrophobic reactions</td>
<td>Try nasal interface or PerforMax or Total face mask, sedate judiciously</td>
</tr>
</tbody>
</table>
The Problem
Skin Integrity during NIV
Saving Face

• As part of the Healthcare Affordability Act, CMS will not reimburse for treatment of Hospital Acquired Pressure Ulcers (HAPU)
• This was a focal topic at the 2011 National Pressure Ulcer Advisory Panel (NPUAP) Meeting
• Key areas are assessment, prevention, monitoring quality indicators, and treatment
Initial Assessment

- All patients should be assessed for skin integrity on admission.
- Assessment of risk factors for HAPU should also be determined on admission and prior to NIV initiation.
  - Braden scale
- Relative risk should determine monitoring frequency and prevention strategy.
Risk Factors for Pressure Ulcer Formation

- Old age
- Dehydration
- Hypotension
- Hypoxemia
- Anemia
- Diabetes
- Atherosclerosis
- Malnutrition
- Vitamin C Deficiency
- Corticosteroid use
Etiology of Pressure Ulcers

• Pressure, Pressure, Pressure
  – Compressive Force
  – Shearing Forces
• Tissue Tolerance
  – Pressure Tolerance
  – Oxygen Tolerance
Pressure Tolerance

• Compressive pressure should be < diastolic BP
  – Secondary goal is < capillary BP (32-45 mmHg)
  – Duration of pressure exposure is extremely important
  – Pressure increases markedly over bony prominences
• Shearing force cause stretching, kinking, and tearing of the perforating vessels in the subcutaneous tissues leading to deeper tissue necrosis
• Presence of shear may reduce pressure tolerance by 50%
Incidence

• Skin Breakdown and pressure ulcer/necrosis is reported to occur in 7-45% of NIV cases that require > 48 hrs of continuous therapy

• Treatment of pressure ulcers ranges from $7,000-40,000 per case
Brief Anatomy and Physiology

- **Epidermis**
  - the outer layer of skin
  - shedding every 21 days

- **Dermis**
  - contains nerve endings, blood vessels, oil glands, and sweat glands. It also contains collagen and elastin.

- **Hypodermis**
  - The subcutaneous tissue is a layer of fat and connective tissue that houses larger blood vessels and nerves.
Pressure Ulcer

- Pressure ulcers are localized areas of tissue necrosis that develop when soft tissue is compressed between a boney prominence surface for an extended period of time.
Stage 1 Pressure Ulcer

Stage 1: Intact skin with non blanchable redness. A change in the skin temp (warm or coolness), tissue consistency (firm or boggy feel) and/or sensation (pain or itching)
Stage 2 Pressure Ulcer

Stage 2: partial thickness loss of skin involving epidermis and/or dermis. Presents as an intact or open serum filled blister or shallow crater.
Stage 3 Pressure Ulcer

Stage 3: Full thickness tissue loss involving damage to or necrosis of subcutaneous tissue that may extend down to, but not through, underlying fascia. Presents as a deep crater. May include undermining or tunneling.
Stage 4 Pressure Ulcer

Stage 4: Full Thickness tissue loss with extensive destruction. Exposed bone, muscle or tendon. Some slough or eschar may be present.
Unstageable Pressure Ulcer
Preventing Pressure Ulcers

- Identify persons at risk
- PREVENTION!!!!
- Consider alternative mask styles
  - PerforMax, Total Face, Gel Mask
- MASK LEAKS ARE A GOOD THING!
  Keep mask leak no less than 7 lpm
- Skin care and early interventions/barriers
- Assessment…Assessment…Assessment
- Staff, Patient, and Family Education
Prevention Strategies

• Adopt a mask rotation schedule in high risk patients
  – Q2-Q4 rotation between FFM and PerforMax (Total)
  – Allows pressure redistribution and offloading
• Encourage PerforMax use
  – Many clinicians are initially skeptical about P-Max
  – Many believe P-Max is only for short-term use
  – P-Max fairs well in patient preference testing
• Use a FFM with a “cut-out” @ nasal bridge
• Encourage/Educate on use of adjustable bridge
• Encourage “prescription” leak with loose fitting mask
Education/Training

- Proper mask selection, sizing, and application
- Leaks may be essential to NIV success
- Mask pressure against the face should be between 3-6 cmH₂O higher than airway pressure
- Use of high acuity BiPAP devices with increased leak compensation and trigger/cycle function
- Mask Fitting Workshop
- Nursing Education
- Physician Education Program
Average volume-assured pressure support
• What is AVAPS
  – Average volume-assured pressure support
  – Vent automatically modifies pressure to maintain an average target user-defined VT
    ▪ 1 cmH$_2$O to possibly 2.5 cmH$_2$O per minute change in pressure
  – 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 automatically adapts pressure support (< 2.5 cmH₂O) per minute to guarantee an average tidal volume.
Proportional Pressure Ventilation (PPV)

• Represents a new mode available during NIV that prioritizes management and response to patient effort, work of breathing and comfort
So what is PPV?

- Proportional Pressure Ventilation = Proportional Assist Ventilation (PAV) as described in multiple peer-reviewed articles
- PPV allows the patient to assist in controlling his own work of breathing
- “PAV (PPV), was developed as a mode to enhance ventilator responsiveness to patient breathing effort”¹
  - Provides inspiratory flow and pressure in proportion to the patient’s spontaneous effort¹
  - A form of synchronized partial ventilatory support designed to generate, on a breath-to-breath basis, inspiratory positive airway pressure in proportion with the patient’s instantaneous inspiratory effort²


What are the advantages of PPV?

- May improve gas exchange short-term in patients with chronic respiratory failure resulting from restrictive thoracic disease or COPD¹
- Reduces work of breathing¹
- Assists in unloading inspiratory muscles, improves gas exchange and provides excellent patient-to-ventilator synchrony in patients with severe, stable COPD¹,²

The difference between PSV and PPV
# Mode Comparison

<table>
<thead>
<tr>
<th>Volume</th>
<th>Pressure</th>
<th>PPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cycled</td>
<td>Support</td>
<td></td>
</tr>
</tbody>
</table>

- **Assist (Airway Pressure)**
- **Patient Effort (Pmus)**

Diagram showing different pressure and volume waveforms for different modes.
Setting PPV parameters

**Active Mode: PPV**

- PPV %: 30
- Max E: 15
- Elast.: 7.5
- Max R: 4
- Resist.: 2.0

**Max V**: 1000 mL

**Max P**: 20 cmH2O

**IPAP**: 10 cmH2O

**Rate**: 4 BPM

**EPAP**: 4 cmH2O

**O2**: 21%

**I-Time**: 1.00 secs

**Rise**: 3
Setting Max E & Max R

Setting PPV %
What Is Auto-Trak+ and Why Is It Needed?

- Auto-Trak+ allows the clinician to adjust Auto-Trak sensitivity thresholds
  - User can adjust the Auto-Trak algorithm for trigger sensitivity
  - User can adjust the Auto-Trak algorithm for E-cycle sensitivity
- The “Normal” setting works well for most patients
  - No need to adjust
- Selected pediatric and adult patients may benefit from Auto-Trak+
  - Pediatrics – may benefit from more sensitive trigger setting
  - Adults – may benefit from more or less E-cycle sensitivity
Advantages of Auto-Trak+

• In selected pediatric and adult patients, altering trigger and cycling settings may:
  – allow for better patient-to-ventilator synchrony
  – help prevent missed triggers in pediatric patients (weak effort)
  – help prevent prolonged I-times seen in some COPD patients
  – help prevent shortened I-times seen in some restrictive lung disease patients

• Auto-Trak+ still has all the same auto-adaptive leak compensation attributes as the standard, non-adjustable Auto-Trak
Cycle Insensitivity

**Problem**: Notice the pressure spikes at the end of each breath indicating added patient effort to cycle the breath from IPAP to EPAP

**Solution**: Increase E-cycle sensitivity setting, and re-evaluate
E-Cycle Too Sensitive

**Problem:** Notice the I-time is quite short, patient may appear to still be inspiring, or patient complains the breath is too short

**Solution:** Decrease E-cycle sensitivity setting, and re-evaluate
C-Flex
What is C-Flex?

• C-Flex is a new 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.
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
• Appropriate use of new modes and features
• Use of specific NIV clinical protocol
Make a difference!