The goal of Noninvasive Ventilation (NIV) is to assist patient ventilation without the need for endotracheal intubation. Although, avoiding intubation often decreases the risks associated with intubation and helps to improve patient comfort, there are also complications associated with the application of NIV. Mask selection and a comfortable fit are key components for successful implementation of NIV and successful patient compliance with NIV therapy. Hospital acquired pressure ulcers (HAPU) have been added to the list of complications that not be reimbursed as part of the new CMS guidelines. This presentation is designed to guide you through the risk factors, prevention strategies, and treatment options for HAPU resulting from mask application during NIV.

The American Association for Respiratory Care has approved this course for 1 continuing education contact hour.
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
There is strong evidence for NIV for patients with CHF, COPD exacerbation, weaning of COPD patients, and immunocompromised patients. There is moderately strong evidence, not as many trials performed, for patients with asthma, cystic fibrosis, postoperative RF, avoidance of extubation failure and DNI patients. The weak evidence, just a few case studies supporting data, for partial upper airway obstruction, ARDS and trauma.
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?
The acute respiratory failure group consisted of a total of 458 episodes in 449 patients. Noninvasive positive pressure ventilation was initiated in the ICU (47%), in the emergency room (20%) and in the medical/surgical unit (33%). The overall need for intubation in this group was 38.4%. Mortality in the failure group was 46.6% compared to 5.4% in the success group. Patients with hypoxemic respiratory failure had a higher mortality rate than the other categories.
The goals of noninvasive ventilation vary depending on the clinical condition. It may be used to alleviate respiratory distress, achieve patient-to-ventilator synchrony or reverse atelectasis. For example, in patients with acute exacerbation the goals are to decrease the work of breathing and reduce CO\textsubscript{2} by augmenting alveolar ventilation; in patients with hypoxemic acute respiratory failure, the goal is to ensure adequate PaO\textsubscript{2}; and in chronic respiratory failure, the goals are to provide sufficient oxygenation and CO\textsubscript{2} elimination to sustain life. Ultimately, the goal of noninvasive ventilation is to provide ventilatory support and to rest fatigued respiratory muscles while the underlying illness is treated or resolved. In addition, noninvasive ventilation helps minimize the risk and complications associated with endotracheal intubation. (12,13,14)
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???
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Utilization of Non Invasive Ventilation in Acute Care Hospitals: A Regional Survey
Vinay Maheshwari, MD; Daniela Painoli, MD; Robert Rothaar, MD; and Nicholas S. Hill, MD, FCCP†
CHEST 2006; 129:1226-1233

• 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.
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

Besides identifying appropriate patients, successful implementation of noninvasive ventilation depends on early intervention, the availability of a skilled health-care team, the use of a comfortable interface, high performance equipment, and appropriate cardiopulmonary monitoring.

First, we have to change our mind set. Every respiratory therapist, nurse and physician should consider noninvasive positive pressure ventilation as the first mode of ventilator support for patients in acute or chronic respiratory failure who do not exhibit any exclusion criteria. The earlier that noninvasive therapy is initiated, the higher the success rate. The question to ask is what is lost by a 30 minute or 1 hour noninvasive positive pressure ventilation trial? NOTHING. You only have something to gain. If a patient’s status deteriorates, he/she can always be intubated. Established protocols, a trained health care team, a wide selection of masks, and availability of high performance equipment are necessary to facilitate early intervention.
RT Time to Initiate and Provide NIV

Kramer et al, Am J Respir Crit Care Med 1995
Although a CPAP device may be used, standard critical care ventilators and bilevel ventilators are the customary choice for the application of noninvasive ventilation. According to Bob Kacmarek, acute respiratory failure success is more likely if patient-ventilator synchrony can be established, the FIO$_2$ can be easily adjusted, and problems with ventilation are monitored and alarmed.

The first bilevel ventilators were designed for outpatient use. Therefore, the units were compact, portable and had fewer features. In comparison to a critical ventilator, some of the bilevel devices delivered lower peak pressures, and have a limited FiO$_2$ range, alarm and monitoring capabilities.

On the other hand, the V60 ventilator was designed specifically for the critical care environment and application of invasive and noninvasive ventilation in the spontaneously breathing patient. Features of the ventilator include bilevel and CPAP modes, graphic displays, leak compensation, backup rate, trigger sensitivity, high pressures and flow rates, and sophisticated alarm and monitoring capabilities. The ventilator also provides stable oxygen delivery up to 100% in 1% increments.
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
The estimated length of therapy, the type of delivery device, safety features, and the patient’s facial features are factors to consider when selecting a mask. For short term use or rapid application, a total face mask or full face mask may be more desirable. Once the patient has stabilized, conversion to a nasal mask may be appropriate. For long-term use, the nasal mask may be more comfortable.

Consider the type of ventilator and circuit used. Some masks are designed to work only with a critical care ventilator and others with bilevel devices. For example, Respironics’ interfaces designed for the V60 and the BiPAP Vision ventilator do not have built-in exhalation ports, because the exhalation port is built-in to the Respironics noninvasive circuit. Using a mask with exhalation ports can cause additional leaks that reduce the flow available to the patient and can interfere with trigger sensitivities and accuracy of displayed patient data.

Safety features of a total or full face mask should include a quick-release for rapid removal of mask, and a safety entrainment feature that allows the patient to breathe room air in case of ventilator failure. Masks used with a single limb circuit require an exhalation port.

The facial features of every patient are unique. The size and shape of the head and nose vary from one patient to another. Skin conditions, such as aging, can cause the facial skin to become fragile and paper thin. Alternating between mask styles or use of the total face mask, which exerts relatively little pressure on the face, may be indicated to prevent pressure sores.
A well-fitting, comfortable interface is critical to the patient’s acceptance of and the overall success of, noninvasive ventilation. Respironics offers a wide variety of mask sizes and designs to help ensure patient comfort, minimize leaks, and improve compliance. There are three basic types of interface: the total face mask, full face mask, and the nasal mask.

The total face mask covers the patient’s whole face, similar to a hockey goalie’s mask. The full face masks are designed to cover the patient’s nose and mouth. The nasal interface is either a small mask that covers the nose or a small cushion that covers the patient’s nostrils. The headgear comes in different sizes and is usually designed for a specific mask. The tension on the headgear straps should be tight enough to achieve an adequate seal, but not so tight it causes pressure sores.
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!
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%
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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 a 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
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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

Will start to talk about AVAPS..
What is AVAPS? AVAPS stands for Average volume-assured pressure support. It is a mode in which the vent automatically modifies pressure to maintain an average target user-defined tidal volume. However, it is changes very slowly from approximately 1 cmH2O to 2.5 cmH2O 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.
As you can see by this representation, AVAPS automatically adapts pressure support to guarantee an average tidal volume less than 2.5 cmH₂O per minute.
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? PPV stands for Proportional Pressure Ventilation. PPV allows the patient to assist in controlling his or her 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 (Mysocki, M.)

What are the advantages of PPV?

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

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So what are the advantages of PPV? Short-term, it can improve gas exchange in patients with chronic respiratory failure resulting from restrictive thoracic disease or COPD.

It can help reduce the work of breathing.

And assist in unloading inspiratory muscles, improve gas exchange and provide excellent patient-to-ventilator synchrony in patients with severe, stable COPD.
As you can see by the graph, the pressure waveform for PSV has a set pressure and does not go above that pressure despite what the patient’s efforts are.

With PPV, the pressure is amplified with the patient’s added inspiratory effort helping the patient to achieve the flow and volume he needs.
PPV: Resistive support (Flow)

Flow (Lpm)

Target P = 10 cmH2O

Target P = 5 cmH2O

Time

For Max R setting of 10 cmH2O/L/Sec
That’s right, as you increase the E-Cycle setting, you decrease inspiratory time. This may result in a decreased delivered VT. Observe the difference in the delivered Vt between the volume curve on the right and the one on the left.
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
Why 6cc? For a typical OSA patient the heart pushes less than 6 cc of air back and forth.
Auto-Trak+ Variable Thresholds for Trigger

Signal shape flow offset for trigger does **not** change with trigger setting changes.

Signal shape flow delayed **not** affected.

Intersection point varies depending on the trigger sensitivity setting.

Signal shape flow offset varies depending on the trigger sensitivity setting.

Patient flow.
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
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!