NON INVASIVE VENTILATION

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Non Invasive Ventilation (NIV)

- Refers to administration of ventilatory support without using an artificial airway (ET tube or Tracheostomy tube).
- Intubation and surgical airway are invasive procedures.
- Use of NIV has markedly increased over the last two decades.
- It avoids some of the adverse effects of invasive ventilation and has the advantage of patient comfort and flexbility.
- NIV applicable in paediatric patients.

Historical Background

- First description of a body ventilator - John Dalziel in 1832
- Cuirass ventilator (1874)
- In the late 1928, Drinker developed the first electrically powered body ventilator *'iron lung' .*
- In 1931, J. H. Emerson, constructed a simpler, quieter, lighter and less expensive version - could be manually operated in the event of power failure.
- Kelleher (1961) 'rotating tank ventilator'

Historical Background

- Till 1950s these ventilators were work horses for polio victims.
- Rudimentary CPAP devices described in 1930s.
- Development of IPPV and ETT in late 50s.
- In 1980s positive pressure delivered through mask in patients with sleep apnoea led to development of NIV

Advantages of NIV

- Ease of application and removal and early ventilatory support
- Patient can cooperate with physiotherapy
- Reduced need for sedation
- Avoidance of complications of endotracheal intubation: upper airway trauma, sinusitis, otitis, nosocomial pneumonia
- Correction of hypoxemia without worsening hypercarbia
- Leaves upper airway intact and preserves defence mechanism

Advantages of NIV

- Allows patient to eat, drink, verbalise and expectorate secretions
- Enhances patient comfort, convenience and portability
- Intermittent ventilation possible
- Can be administered outside ICU
- Simplifies care of patients with CRF at home
- Ease to teach paramedics and nurses

TYPES OF NONINVASIVE VENTILATION

- **Negative pressure ventilators**

- **Positive pressure ventilators**

Negative pressure ventilators

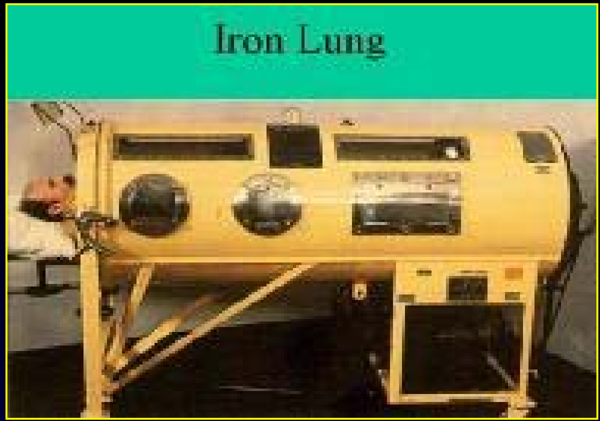
- Supports ventilation by lowering the pressure surrounding the chest wall during inspiration and reversing the pressure to atmospheric level during expiration.

•Iron lung / tank ventilator

•Cuirass

•Pneumojacket / pnuemosuit

•Hayeks oscillator



Iron lung / tank ventilator

- Tank-type negative-pressure ventilators, mainstay of ventilatory support during the polio epidemics in the 1950's.
- Bulky and heavy.
- More portable fiberglass tank ventilator - now available
- The most commonly used - is the poncho wrap (or jacket) ventilator - an impermeable nylon jacket with rigid chest piece . Lightweight- must be connected to negative-pressure generators.

Iron Lung

Cuirass

- The cuirass (or tortoise shell) ventilator - consists of a rigid plastic or metal dome over the chest and abdomen
- More portable and not as restrictive.
- Applies negative pressure over only a portion of chest and abdomen ,so less efficient

Hayeks oscillator

- External high frequency ventilation
- Chest and abdominal cuirass connected to oscillator – delivers pressures ranging from -70 to +70 cm H20 at freq 60/min for ventilation and 999/min for secretion removal .

I:E ratio can be from 6:1 to 1:6

Abdominal displacement ventilators

- Rocking Bed – relies on displacement of abdominal contents to assist diaphragm motion.
- Rocking rate 12-24/min adjusted to optimise patient comfort and MV.
- Advantages: ease of operation , patient comfort, lack of encumbrances

Pneumobelt

• A corset-like device - wraps around pt midsection , pushes the diaphragm up to assist breathing on exhalation

•Ineffective unless pt is sitting-up.

•Day time adjunct

Non Invasive Positive pressure ventilators

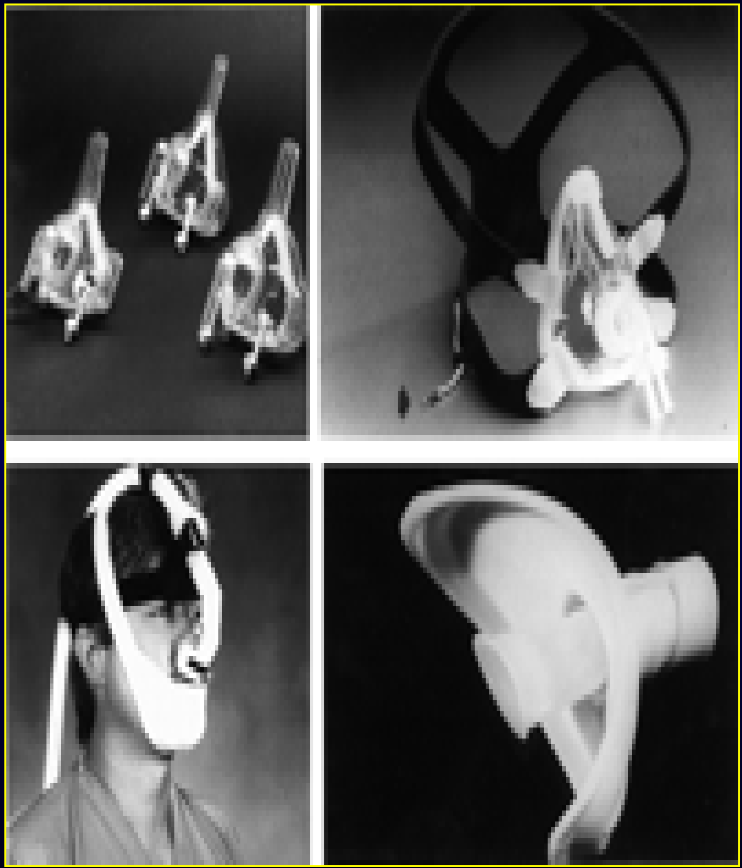
- Inspiration takes place with the application of positive pressure to the upper airway either by using conventional ventilator or specialised NPPV equipment.
- Expiration takes place by elastic recoil of the chest and the lung

Mechanism of action

- NPPV decreases the WOB
- Improves alveolar ventilation while simultaneously resting the respiratory musculature.
- RR falls as TV is augmented.
- lowers LV transmural pressure, CPAP may ↓ after load and ↑CO - modality for therapy of acute pulmonary edema.

- In CHRONIC RESP FAILURE –three theories
- NIV rests chronically fatigued muscles improving day time function
- In addition, NIV improves resp system compliance by reversing microatelectasis
- NIV lowers the resp centre ‘set point’ for CO_2 by ameliorating chronic hypoventilation

Equipment - Interfaces



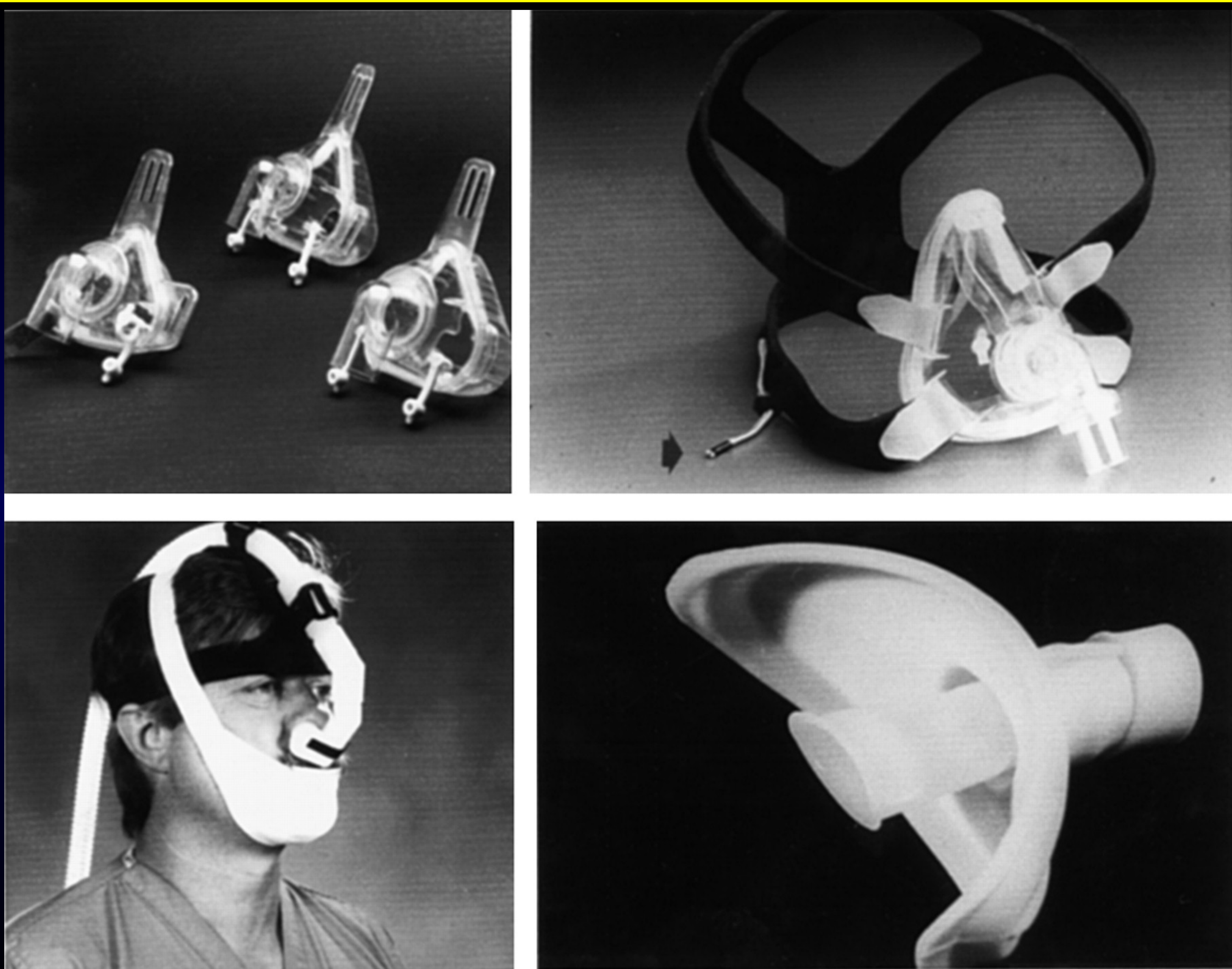
NPPV is delivered to the airway via an ***interface*** — device which connects ventilator tubings to the face that facilitates entry of pressurized gas into upper airway

-Nasal masks

-Oronasal masks

-Nasal pillows

-Mouth pieces



Interface	Advantage	Disadvantage
Nasal mask	Good for long term use	Difficult in pt with mouth leak, nasal pathology
Full face mask	Useful in those with mouth leaks	Claustrophobic, aspiration
Nasal plugs	Helpful in claustrophobic pts	Unstable,slips
Customised	Improved fit, decreased dead space	Costly, time to construct

- The efficacy of nasal and oronasal masks - compared in a controlled trial of 26 patients with stable hypercapnia caused by COPD or restrictive thoracic disease.

- The nasal mask was better tolerated but was less effective at lowering $PaCO_2$, perhaps because of greater air leaking .

TYPES OF VENTILATORS USED FOR NPPV

- CONVENTIONAL VENTILATORS
- NPPV VENTILATORS

Conventional ventilators

- Advantages
- Monitoring backup
- Backup ventilation present Fi$\mathbf{O}_2$ can be set
- Alarms can be set
- Separate inspiratory & expiratory limb prevents rebreathing
- Inspiratory pressures of more than 20 cm of H_2O can be set.
- Disadvantages
- Expensive
- Less flexible & portable
- Leak compensation not present, hence requires a tight interface

NPPV Ventilators

Advantages

- Flexible& portable
- Cheaper
- Good Leak compensation hence doesnot require a tight interface which enhances patient comfort
- Inspiratory pressure of 20cmH_2O is the maximum available

Disadvantages

- Due to leak requires high O2 flows.FiO2 can not be set
- Due to single limb, rebreathing occurs

MODES OF NON INVASIVE POSITIVE PRESSURE VENTILATION

- <u>Volume mechanical ventilation</u>

  Usually breaths of 250 – 500 ml (4 -8 ml/kg) . Pressures vary
- <u>Pressure mechanical ventilation</u>

  Usually pressure support or pressure control at 5 – 20 cm of water. End expiratory pressure at 0 – 6 cm of water. Volumes vary.
- <u>Bilevel positive airway pressure (Bilevel PAP)</u>

  Usually inspiratory pressure of 6 – 14 cm of water and expiratory pressure of 3 – 5 cm of water. Volumes vary
- <u>Continuous positive airway pressure (CPAP)</u>

  Usually 5 – 12 cm of water. Constant pressure, volumes vary

Volume vs Pressure Preset Ventilators

	Volume preset	Pressure preset
Delivery	Constant TV	TV changes with resistance and compliance
Leak compensation	poor	good
Addition of PEEP/EPAP	Can add PEEP	EPAP on bilevel machines
Peak airway pressure	Difficult to limit	Can preset max IPAP
Size	bulky	smaller

CPAP

- Not a true ventilator mode.
- Delivering a constant pressure during both inspiration and expiration.
- Pressures commonly used to deliver CPAP -range from 5 to 12.5 cm H_2O.
- CPAP may be administered using "demand," "flow-by," or "continuous flow" techniques.

BIPAP

- BIPAP ventilators referred to as "bilevel" devices
- Provide continuous high-flow positive airway pressure that cycles between a higher and a lower positive pressure
- Expiratory pressure - equivalent to the PEEP
- Inspiratory pressure - equivalent to the sum of the PEEP and the level of pressure support.

Proportional Assist Ventilation

- New ventilator mode which targets patient effort rather than pressure or volume .
- By tracking patient inspiratory flow and its integral volume using an in-line pneumotachograph, this mode has the capability of responding rapidly to the patient's ventilatory effort.

GOALS OF NONINVASIVE VENTILATION

Short-term (including acute)

1. Relieve symptoms
2. Reduce work of breathing
3. Improve or stabilize gas exchange
4. Optimize patient comfort
5. Good patient-ventilator synchrony
6. Minimize risk
7. Avoid intubation

Long-term

1. Improve sleep duration and quality
2. Maximize quality of life
3. Enhance functional status
4. Prolong survival

TYPES OF RESPIRATORY FAILURE TREATED WITH NONINVASIVE VENTILATION

- Obstructive
  COPD
  Asthma
  Cystic fibrosis
  Upper airway obstruction
- Restrictive
  Chest wall deformity
  Neuromuscular diseases
  Obesity hypoventilation
- Parenchymal
  AIDS-related pneumonia
  ARDS
  Infectious pneumonia
- Cardiogenic
  Acute pulmonary edema

RESTRICTIVE THORACIC DISEASES NONINVASIVE VENTILATION

Chest wall deformity

- Kyphoscoliosis
- Thoracoplasty for tuberculosis

Slowly progressive neuromuscular disorders

- Postpolio syndrome
- Slowly progressive muscular dystrophies
- High spinal cord injury
- Multiple sclerosis
- Spinal muscular atrophy
- Bilateral diaphragm paralysis

RESTRICTIVE THORACIC DISEASES NONINVASIVE VENTILATION

More rapidly progressive neuromuscular disorders

- Duchenne muscular dystrophy
- Amyotrophic lateral sclerosis

Rapidly progressive neuromuscular disorders

- Guillain-Barré syndrome
- Myasthenia gravis

SELECTION GUIDELINES NIV FOR PATIENTS WITH COPD AND ARF

Step 1. Identify patients in need of ventilatory assistance:

A. **Symptoms and signs of acute respiratory distress:**

a. Moderate to severe dyspnea, increased over usual and,

b. RR > 24, accessory muscle use, paradoxical breathing

B. Gas exchange abnormalities:

a. $PaCO_2 > 45$ mm Hg, pH < 7.35 or

b. $PaO_2/FIO_2 < 200$

SELECTION GUIDELINES:

Step 2. **Exclude those at increased risk with non invasive ventilation:**

- Respiratory arrest
- Medically unstable (hypotensive shock, uncontrolled cardiac ischemia or arrhythmias)
- Unable to protect airway
- Excessive secretions
- Agitated or uncooperative
- Facial trauma, burns, or surgery, or anatomic abnormalities interfering with mask fit

INITIATION OF NIPPV

1. Appropriately monitored location.
2. Patient in bed or chair sitting at 30-degree angle
3. Select and fit interface
4. Select ventilator
5. Apply headgear; avoid excessive strap tension
6. Start with low pressures/volumes in spontaneously triggered mode with backup rate;

   - Pressure-limited: 8 to 12 cm H_2O inspiratory;

     3 to 5 cm H_2O expiratory

   - Volume-limited: 10 ml/kg

7. Gradually ↑ IP (10 to 20 cm H_2O) or TV (10 to 15 ml/kg) as tolerated to alleviate dyspnea, ↓RR, ↑ TV and good patient-ventilator synchrony

8. Provide O_2 supplementation to keep O_2 sat > 90%

9. Check for air leaks, readjust straps as needed

10. Add humidifier

11. Consider mild sedation in agitated patients

12. Encouragement, reassurance

13. Monitor blood gases

MONITORING PATIENTS ON NIPPV

- **SUBJECTIVE RESPONSES:**
- **Monitoring** of patient comfort and tolerance are key.
- In Acute setting-alleviation of respiratory distress.
- In Chronic setting-alleviation of fatigue, hypersomnolence ,headache.

- PHYSIOLOGICAL RESPONSES:
- Drop in the respiratory rate within the first hour or two.
- Patients breath in synchrony with the ventilator and scm muscle activity diminishes.
- Abdominal paradox subsides .Fall in HR
- Air leaking & patient ventilator asynchrony
- Monitor tidal volumes-aim for >7ml/kg

Monitoring Gas Exchange

- Aim is to maintain adequate oxygenation while awaiting an improvement in ventilation
- In Acute setting :continuous oximetry
- ABG: should be delayed until the patient is consistently using the ventilator for at least 4-6hrs
- Noninvasive CO_2 monitoring -inaccurate

PREDICTORS OF SUCCESS DURING ACUTE APPLICATIONS OF NIPPV

- Younger age
- Lower acuity of illness (APACHE score)
- Able to cooperate; better neurologic score
- Able to coordinate breathing with ventilator
- Less air leaking, intact dentition
- Hypercarbia, but not too severe ($PaCO_2$ > 45 mm Hg, and < 92 mm Hg)
- Acidemia, but not too severe (pH < 7.35 and > 7.10)
- Improvements in gas exchange , heart and respiratory rates within first 2 h

CRITERIA FOR FAILURE OF NIPPV

1. The presence of one major criterion is an indication for immediate intubation.

2. Presence of two minor criteria after one hour of treatment is an indication for intubation.

Major Criteria

- Respiratory arrest
- Loss of consciousness
- Psychomotor agitation requiring sedation
- Haemodynamic instabillity with systolic BP<70 or>180mmHg
- Heart rate<50beats/min with loss of alertness

Minor Criteria

- RR>35breaths/min & higher than the value recorded on admission
- Arterial pH<7.30 and is lower than the value on admission Pa O_2 <45 mm Hg despite oxygen supplementation.
- Deterioration of one or more points on the neurological score.
- Presence of weak cough reflex with accumulation of secretions.

ADVERSE SIDE EFFECTS AND COMPLICATIONS OF NIPPV

Mask related

- Discomfort
- Facial skin erythema
- Claustrophobia
- Nose bridge uleration

Air pressure /flow related

- Nasal congestion
- Sinus/ear pain
- Nasal /oral dryness
- Eye irritation
- Gastric insufflation
- Air leaks

Major Complications

- Aspiration pneumonia
- Hypotension
- Pneumothorax

COPD

- Patients with exacerbations of COPD - the largest single diagnostic category among reported recipients of NIPPV.
- Acute exacerbation –significant mortality
- Risk of complication ,VAP following intubation
- Intubated patients ,subsequently prove difficult to wean
- Success rates in avoiding intubation range - 58 to 93% with NIV

Community-acquired pneumonia

Patients treated with NIPPV had

- Reduced intubation rates and
- A shorter duration of ICU stay and length of Hospital stay
- Mortality rates are similar.

Hypoxemic Respiratory Failure

- Use of NIPPV in patients with hypoxemic respiratory failure - conflicting results

Wysocki and colleagues found that

- 7 of 8 patients with $PaCO_2$ values < 45 mm Hg failed NIPPV,
- 7 of 9 with initial $PaCO_2$ values > 45 mm Hg - successfully treated.
- NPPV ↓ intubation rate, length of ICU stay, and ICU mortality among the hypercapnic patients.
- Implication - hypoxemic respiratory failure without CO_2 retention responds poorly to NPPV

ACUTE ASTHMA

- No randomized trials

In the largest uncontrolled trial

- 17 patients with asthma with average initial pH of 7.25 and a $PaCO_2$ of 65 mm Hg were treated with NPPV.
- Only 2 patients required intubation for hypercapnia.
- The average duration of ventilation was 16 hours, and no complications occurred.
- Conclusion - NPPV appears to be an effective ventilatory modality in correcting gas exchange abnormalities

Acute Pulmonary Odema

- Noninvasive CPAP in 4 randomized prospective trials - an effective therapy for acute pulmonary edema.
- significant improvements in vital signs and gas exchange as well as drastic ↓ in intubation rates attributed to use of CPAP (10 to 12.5 cm H_2O) via a face mask
- average intubation rates dropped to 19% from 47% in control subjects.

Chest Trauma

- CPAP and regional analgesia were compared with immediate intubation and IPPV with PEEP in trauma pt with moderate lung injury.
- CPAP resulted in
  - fewer treatment days
  - $\downarrow$ mean ICU days and hospital days
- CPAP should be used in patients with chest trauma who remain hypoxic even after regional analgesia and use of high flow oxygen

Facilitation of weaning

- NPPV has been used to accelerate and facilitate weaning in patients who do not meet the standard criteria for extubation.

- A trial of NPPV may be given if patient is fully alert with an easy airway and sufficient muscle strength

Postoperative Patients

- Pennock and colleagues found that nasal ventilation using the BiPAP device avoided reintubation in 73% of 22 patients who had respiratory deteriorations at least 36 h after various types of surgery

Do-Not-Intubate Patients

- NPPV has been used in patients who are reluctant to undergo intubation.
- Benhamou and colleagues studied 30 patients, most elderly and with COPD, in whom ET was "contraindicated or postponed."
- Despite severe respiratory failure (mean Pa_{O2}, 43 mm Hg and Pa_{CO2}, 75 mm Hg), NPPV was initially successful in 60% of cases

Restrictive and Neuromuscular diseases

- Numerous studies on efficacy of nasal NPPV in various neuromuscular and chest wall diseases been published
- Pts showed improvements after a few weeks of nocturnal nasal ventilation in

  - Daytime gas exchange

  - Symptoms of fatigue, daytime hypersomnolence and

  - Morning headaches

Central Hypoventilation and Obstructive Sleep Apnea

photo courtesy of the American Sleep Apnea Association

- Nasal CPAP is considered the therapy of first choice.

- NPPV may be also successful in improving daytime gas exchange and symptoms in patients with OSA who continue to hypoventilate after use of nasal CPAP alone

CONCLUSION

- NIV is a safe and effective means of augmenting ventilation in a variety of clinical conditions.
- When faced with a patient who may benefit from NIV, it works best when instituted early.
- After initiation, have a clear plan on how to recognize a treatment failure and what to do for those who fail. Close monitoring is essential especially in the initial period.
- There is no convincing evidence that a failed trial of NIV is harmful.
- NIV should be viewed as a means of preventing rather than a alternative to endo tracheal intubation and mechanical ventilation.
- The availability of newer equipment designed for use in ICU and non ICU settings have widened the horizons of its use

THANK YOU