Basics of NIV

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Objectives:

- Definitions
- Advantages and Disadvantages
- Interfaces
- Indications
- Contraindications
- Modes

Definition

- Non-invasive ventilation (NIV) refers to the delivery of mechanical ventilation to the lungs using techniques that do not require an invasive artificial airway(ETT, TT)

NIV - Advantages

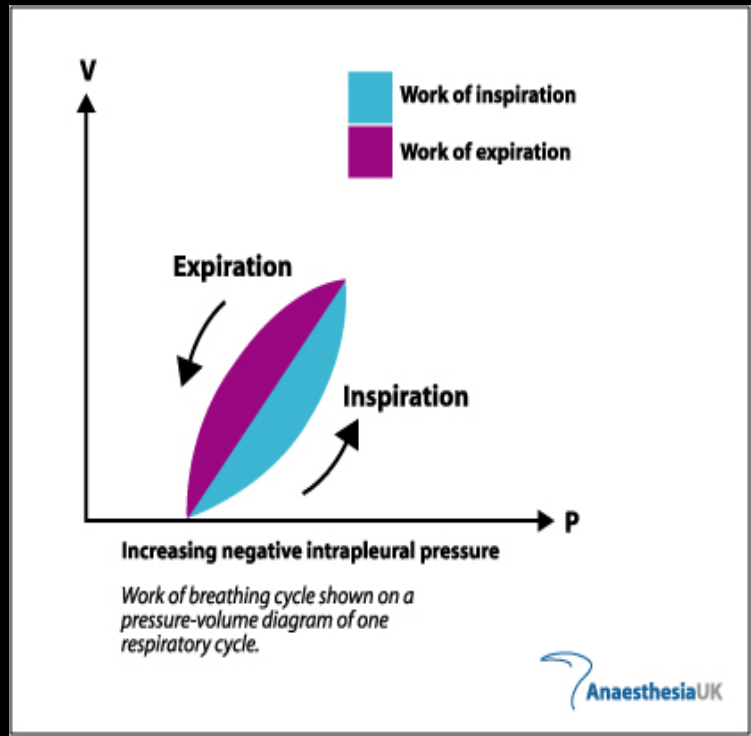
- Non invasiveness
  - Flexibility in initiating and removing mechanical ventilation
  - Allows intermittent application
  - Improves patient comfort
  - Reduces the need for sedation
  - Oral patency
- Preserves speech, swallowing and expectoration, reduces the need for nasogastric tubes

Advantages

- Avoid the resistive work imposed by the ETT
- Avoids the complications of endotracheal intubation
  - Early (local trauma, aspiration)
  - Late (injury to hypopharynx, larynx, and trachea, nosocomial infections)
- Reduces infectious complications- pneumonia, sinusitis, sepsis
- Less cost
- Accelerates weaning

MECHANISM OF ACTION OF NPPV

- The work of breathing equals the product of pressure change across the lung and volume of gas moved.
- During inspiration, most of the work is done to overcome elastic recoil of the thorax and lungs, and the resistance of the airways and non-elastic tissues.



MECHANISM OF ACTION OF NPPV

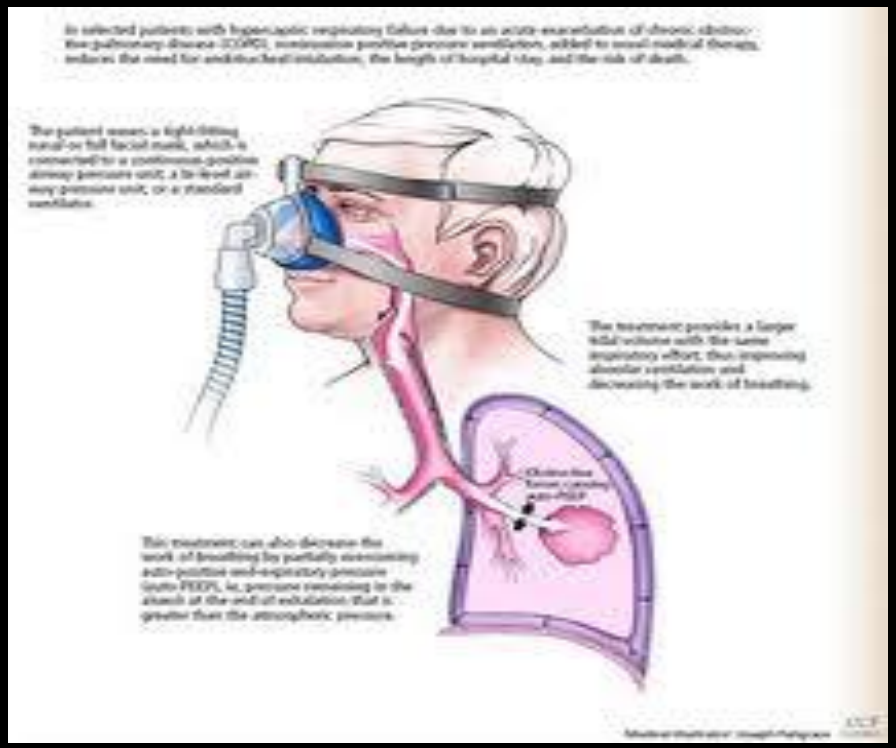
1. Improvement in pulmonary mechanics and oxygenation:
   - NIV augments alveolar ventilation and allows oxygenation without raising the $PaCO_2$
2. Partial unloading of respiratory muscles:
   - NIV reduces respiratory muscle work and diaphragmatic electromyographic activity.
   - This leads to ↑ TV, ↓ RR and ↑ MV.
   - Also overcomes the effect of intrinsic PEEP.

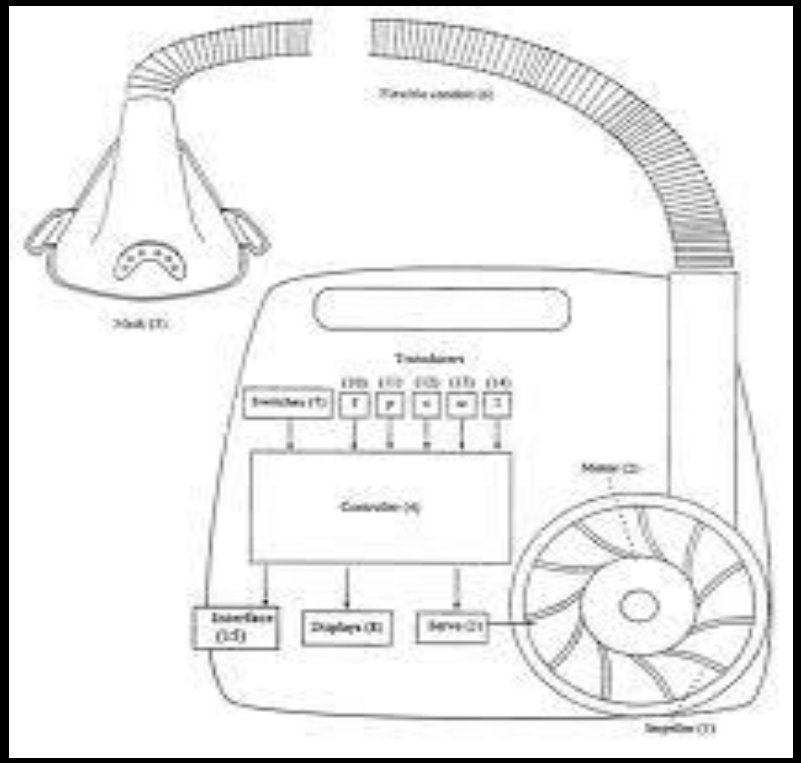
MECHANISM OF ACTION OF NPPV

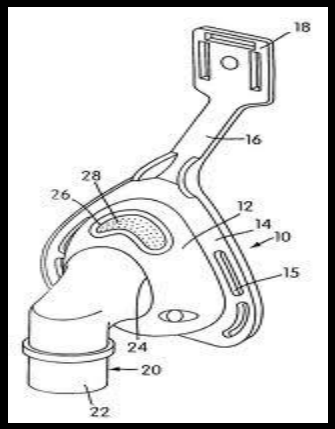
3. Resetting of respiratory centre ventilatory responses to $PaCO_2$:
   - By maintaining lower nocturnal $PaCO_2$ during sleep by NIV, it is possible to reset the respiratory control centre to become more responsive to an increased $PaCO_2$ by increasing the neural output to the diaphragm and other respiratory muscles
   - These patients are then able to maintain a more normal $PaCO_2$ throughout the daylight hours without the need for mechanical ventilation

NON INVASIVE POSITIVE PRESSURE VENTILATION

- During NIPPV, air enters the nose, mouth or both through the interface, which in turn is connected, to Positive Pressure Ventilator.







INTERFACES

- Devices that connect ventilator tubing to the face, allowing the entry of pressurized gas to the upper airways.
- Masks are usually made from a non-irritant material such as silicon rubber.
- Proper fitting mask is crucial to minimize leaks, improve patient compliance and for maximum therapeutic benefit
- It should have minimal dead space and a soft inflatable cuff to provide a seal with the skin.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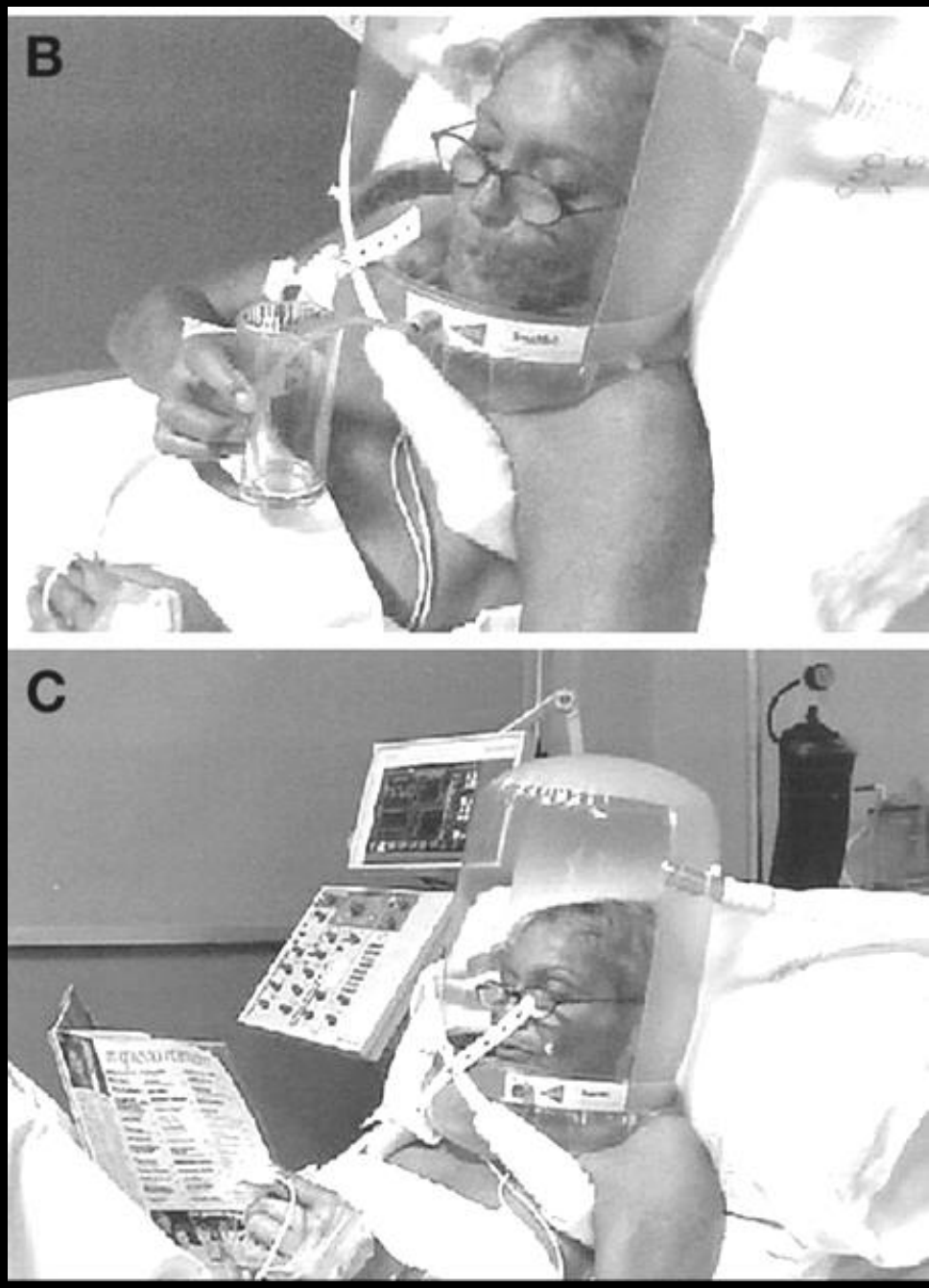
Types of interfaces

- Nasal interfaces:-
  - Nasal masks, nasal cannulae or nasal cushions (within nostrils)
  - There are two basic forms of nasal interface tubes; non-sealing nasal interface tubes for supplemental oxygen therapy and sealing nasal interface tubes for PAP ventilation.
- Oral interfaces
- Combined oral and nasal interfaces
- Helmets

Variable	Nasal	Oronasal
Comfort	+++	++
Claustrophobia	+	++
Rebreathing	+	++
Lower CO2	+	++
Permits expectoration	++	+
Permits speech	++	+
Permits eating	+	-
Functions if nose obstructed	-	+

Helmets

- Allows prolonged continuous application of NIV
- Lesser complications like skin necrosis, gastric distension, and eye irritation



CONTRAINDICATIONS

- Inability to protect airway:-
  - CVA, comotose patients, confused agitated patients
- Hemodynamic instability:-
  - Recent MI, arrhythmias, high dose inotropes
- Inability to fix the interface:-
  - facial -abnormalities, burns, trauma, anamolies
- Severe GI symptoms:-

  - severe Upper GI bleed

CONTRAINDICATIONS

- Life threatening hypoxemia
- Copious secretions
- Conditions where NIV has not been found effective
- Non availability of trained medical personnel

Requirements for successful non-invasive support

1. A co-operative patient who can control their airway and secretions with an adequate cough reflex. The patient should be able to co-ordinate breathing with the ventilator and breathe unaided for several minutes.
2. Hemodynamically stable
3. Blood pH >7.1 and $PaCO_2$ <92 mmHg
4. The patient should ideally show improvement in gas exchange, H.R and R.R within first two hours.

INDICATIONS OF NPPV

A) Acute respiratory failure

1. Hypercapnic acute respiratory failure

- COPD (Evidence A)
– Facilitation of weaning in COPD (Evidence A)
– Asthma (B)
– Extubation failure in COPD (B)
– Cystic Fibrosis (C)
– OSA/obesity hypoventilation (C)
– Upper airway obstruction (C)

Cochrane Database Syst Rev. 2013;5:CD005351.

INDICATIONS OF NPPV

- 2)Hypoxemic acute respiratory failure
  - Acute pulmonary edema- CPAP (Evidence A)
  - Immunocompromised patients (Evidence A)
  - Postoperative patients (B)
  - ARDS (C)
  - Pneumonia (C)
  - Trauma or burns (C)
  - Restrictive thoracic disorders (C)
  - Do not intubate patients (C)
  - During bronchoscopy (C)

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NIV in weaning from mechanical ventilation

- It serves as a bridge between invasive support and spontaneous breathing to reduce the time on invasive mechanical ventilation.
- Uses
  - As a part of early weaning strategy, when SBT fails
  - After conventional weaning and extubation to prevent post extubation failure
  - When signs of respiratory failure develop after extubation

Determinants of success for NPPV

- Synchronised breathing with ventilator
- Dentition intact
- Lower APACHE score
- Less air leaking
- Less secretions
- Good initial response to NPPV at 1-2 hrs
- Correction of pH
- Reduction in respiratory rate
- Reduction in $PaCO_2$
- No pneumonia
- pH>7.10 (b/w 7.1-7.35)
- $PaCO_2$ < 92mm Hg
- Better neurologic score
- Better compliance

PATIENT SELECTION

- **Step 1**

– An etiology of respiratory failure likely to respond favourably to NIV

- **Step 2**

– Identify patients in need of ventilatory assistance by using clinical and blood gas criteria

– Moderate to severe dyspnea, tachypnea, and impending respiratory muscle fatigue

– COPD with RR >24 bpm

– Hypoxemic respiratory failure with RR >30-35 bpm

- **Step 3**

– Exclude patients for whom NIV would be unsafe

SELECTION CRITERIA

A) ACUTE RESPIRATORY FAILURE

At least 2 of the following criteria must be present

- Respiratory distress with dyspnoea
- Use of accessory muscles of respiration
- Abdominal paradox
- Respiratory rate > 25/min
- ABG shows pH< 7.35 or $PaCO_2$ >45 mmHg or PaO_2/FiO_2 <200

SELECTION CRITERIA

B) CHRONIC RESPIRATORY FAILURE(OBSTRUCTIVE LUNG DISEASE)

- Fatigue, Hypersomnalence, dyspnoea
- ABG shows Ph<7.35. Paco2>55 mmHg
- Oxygen saturation <88% for >10% monitoring time despite O2 supplementation

C) THORACIC RESTRICTIVE/CEREBRAL HYPOVENTILATION DISEASES

- Fatigue, morning headache, hypersomnalence, nightmares, enuresis, dyspnoea
- ABG shows PaCo2 >45 mmHg
- Nocturnal SaO2 <90% for more than 5 minutes sustained

When to intubate during NIV???

- No improvement in gas exchange or dyspnoea progressively increases
- Deterioration or no change in the mental condition of the hypercapnoeic patients
- Need for airway protection
- Hemodynamic instability
- Fresh MI or arrhythmias
- Patient unable to tolerate the mask

Equipment for NIV

- Ventilators
- Portable NIV machines
  - Advantages
    - Portability
    - Ease of use
    - Better compensation for leaks
    - Better exhalation
  - Disadvantages
    - Cannot develop pressures >30cm H2O
    - Lack O2 blenders
    - Lack of sophisticated alarm systems, battery backup
- Critical care ventilators

Ventilators for NIV

- Volume controlled home ventilators
  - First machines to be used
  - Limited ability to compensate for leaks
- Bilevel ventilators
  - Most commonly used
  - EPAP & IPAP
  - Single limb circuit
  - Good efficiency & leak compensation
- ICU ventilators – Limited leak compensation

Modes of NIV

- **Pressure modes**

– Better tolerated than volume-cycled vents

❖ Constant positive airway pressure(CPAP)

❖ Bilevel or biphasic positive airway pressure (BiPAP)

❖ Pressure support ventilation(PSV)

- **Volume modes**

– Initial tidal volumes range from 10 to 15 mL/kg

❖ Control

❖ Assist control

❖ Proportional assist control

CPAP

- A mode for invasive and non invasive mechanical ventilation

- Provides static positive airway pressure throughout the respiratory cycle- both inspiration & expiration

- Facilitates inhalation by reducing pressure thresholds to initiate airflow

CPAP

- Creates a "pneumatic splint" for the upper airway, preventing the soft tissues of the upper airway from narrowing and collapsing.
- Increase functional residual capacity
  - Improve lung compliance
  - Open collapsed alveoli
  - Improve oxygenation
  - Decrease work of breathing
- Decrease left ventricular transmural pressure, ↓ afterload and ↑CO

BiPAP– Spontaneous

- Airway pressure cycles between an inspiratory positive airway pressure (IPAP) and an expiratory positive airway pressure (EPAP)
- Difference between IPAP and EPAP is the PS
- Trigger- patient effort
- Limit - set level of IPAP
- Cycling - cessation of patient effort(decrease in inspiratory flow rate, or a maximum inspiratory time reached - typically 2 - 3 seconds)

BiPAP – Spontaneous

- Vt varies breath to breath based on degree of IPAP, patient effort, and lung compliance
- IPAP should be > EPAP by a minimum of 4cm H2O
- Dependant on patient effort to trigger inhalation. Slow efforts- respiratory acidosis.
- BiPAP can be described as a continuous positive airway pressure system with a time -cycled or flow -cycled change of the applied CPAP level

BIPAP-Spontaneous/timed (ST) mode

- Trigger in the ST mode can be the patient's effort or an elapsed time interval, predetermined by a set respiratory backup rate.
- If the **patient does not initiate a breath** in the prescribed interval, then IPAP is triggered.
- For machine generated breaths, the ventilator **cycles back to EPAP based on a set inspiratory time.**

BIPAP-Spontaneous/timed (ST) mode

- For patient-initiated breaths, the ventilator cycles as it would in the spontaneous mode.
- Increases in inspiratory pressure are helpful to alleviate dyspnea
- Increases in expiratory pressure are better to improve oxygenation

Application of NIV

1. Choose the correct interface

2. Explain therapy and its benefit to the patient in detail . Also discuss the possibility of intubation

3. Set the NIV ventilator to Spont or S/T mode

4. Start with very low settings. Start low IPAP of 6-8 cm H2O and EPAP of 2-4 cm H2O. The difference between IPAP and EPAP should be atleast 4 cm H2O.

5. Administer oxygen at 2 liters per minute.

6. Hold the mask with hand over face. Do not fix it

7. Increase EPAP by 1-2 cm increments till all the inspiratory efforts are able to trigger the ventilator

8. If the pt. is making inspiratory effort & the ventilator is not responding, it indicates that the pt has not generated enough respiratory effort to counter auto PEEP and trigger the ventilator. Increase EPAP further till it happens. Most of the pt require EPAP of about 4 to 6 cm H2O.

9. When the patients efforts are triggering the ventilator leave EPAP at this level

10. Now start increasing IPAP in increments of 1-2 cm H_2O up to a maximum pressure, which the patient can tolerate without discomfort

11. In some ventilators, inspiratory time (Ti) can be set. Setting Ti at one second is reasonable

12. Now secure interface with head straps. Avoid excessive tightness

13. After titrating pressure increase Oxygen to bring SaO2 to around 90%.

14. As the settings may be different in wakefulness and sleep, readjust them accordingly

FiO_2 Setting:

- Initial FiO_2 is to be slightly higher than that received prior to NIV.
- Then it is adjusted to achieve desired SaO_2, generally above 92%.

Documentation

- Mode of ventilation
- Flow rate of oxygen, percentage of oxygen
- TPR and BP
- Respiratory assessment
- Conscious level (GCS)

Observe - 15 minutely for first hour, then hourly if condition stable

Monitoring response

Physiological

a) Continuous oximetry
b) Exhaled tidal volume
c) ABG- Initial, 1, 2-6 hrs

Objective

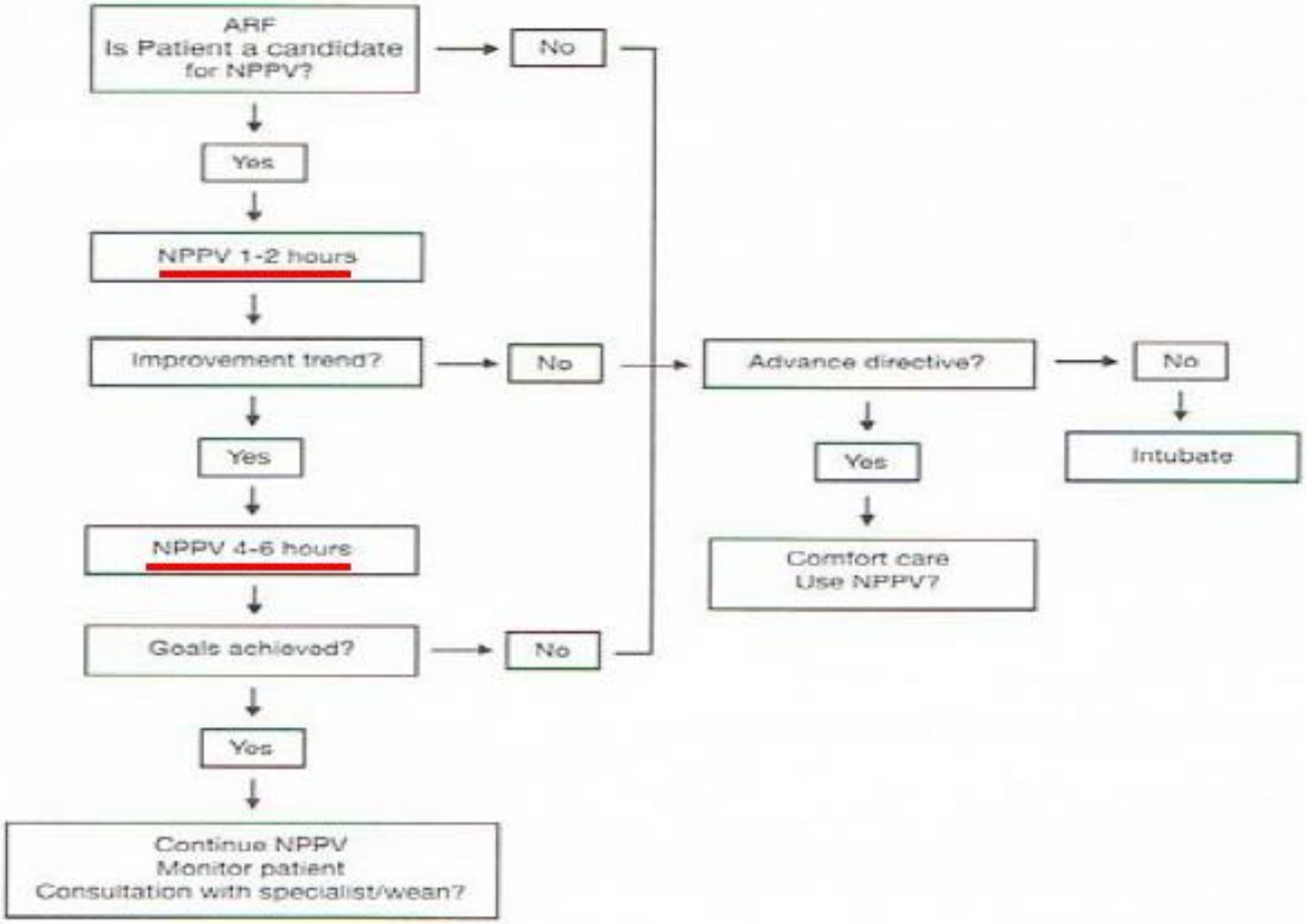
a) Respiratory rate
b) Chest wall movement
c) Coordination of respiratory effort with NIV
d) Accessory muscle use
e) HR and BP
f) Mental state

Subjective

a) Dyspnoea
b) Comfort

- If the patient is getting increasingly tired, or ABG deteriorates despite optimal settings, then mechanical ventilation is necessary. It must be recognized early.

Assessment of NIV



Criteria to discontinue NIV

- Inability to tolerate the mask
- Inability to improve gas exchange or dyspnoea
- Need for endotracheal intubation
- Hemodynamic instability
- ECG – ischaemia/arrhythmia

Duration of treatment

- Patients who **benefit from NIV during the first 4 hours** of treatment should receive NIV for **as long as possible (a minimum of 6 hours) during the first 24 hours** (**Evidence A**)
- Treatment should last until the acute cause has resolved, commonly after about 3 days
- When NIV is successful (pH>7.35,resolution of cause, normalisation of RR) after 24 hrs/more –plan weaning

Withdrawal of NIV

- Clinical improvement
- Aim for
  - RR<24
  - HR <110
  - pH>7.35
  - Sats >90% on <40%

Drug Delivery during NIV:

- Inhaled drugs can be administered during NIV by adding a nebulizer to the circuit.

- This can be done by using a T-piece positioned as close as possible to the patient, ideally between the exhale valve and the patient to prevent fallout and loss of the drug, although this does increase the dead space.

- The optimum nebulizer position during NIV is between the leak port and the mask.

- The nebulizer dose may need to be increased if the leak port is in the mask.

- Most nebulizers are suitable, but a nebulizer that is able to work at varying angles is useful as often the ventilator circuit is unsupported, leaving the nebulizer to function on its side.

- Aerosols can also be administered into the ventilator circuit using metered dose inhalers and spacer devices especially when the leak port is in the mask.

Problems and complications

A. PROBLEMS RELATED TO THE INTERFACE:-

Improperly fitting mask, excess strap tension, claustrophobia, pressure over nasal bridge

B. PROBLEMS ASSOCIATED WITH AIRPRESSURE AND FLOW:-

- Air leaks- oral dryness, eye irritation
- Air pressure – redness & congestion of nose & PNS
- Gastric distension

Problems and complications

C. Problems associated with intolerance to NIV:
   - Mask intolerance
   - Patient ventilator asynchrony

D. Problems associated with failure to ventilate adequately:
   - Air leak
   - Rebreathing of CO_2
   - Position of exhalation valve affects dynamic dead space

Problems and complications

E. Major complications:

- Delay in intubation and worsening of prognosis
- Major desaturation and cardiac arrest
- Aspiration pneumonia
- Hypotension
- Pneumothorax

Conclusion

- NIV is an important tool to tide over an acute insult in the hands of a experienced operator
- Key factors in success
  - Evidence based application for selected etiologies
  - Careful patient selection/rejection
  - Skilled initiation & application
  - Algorithmic approach in initiation, use, discontinuation
  - Patient comfort & avoiding dyssynchrony
  - Avoiding complications
- Most importantly
  - Decision making on **when** to switch to invasive mechanical ventilation in a setting of failure of NIV

THANK YOU