중증 천식 악화로 인한 호흡 부전에서 비침습적 기계환기 요법이 효과가 있는가?

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50 year old woman, a known asthmatic for the past 30 years, presented to the emergency department with a 2 day history of worsening breathlessness and cough.

There was no fever, expectoration, chest pain, haemoptysis, or limb swelling.

Pulse rate 126 beats/min, blood pressure 150/94 mm Hg. Respiratory rate 35 breaths/min with accessory muscles of respiration in use.

Chest auscultation revealed bilateral polyphonic inspiratory and expiratory wheeze.

Introduction

- Despite the continuous improvement in the therapeutic strategy for asthma, severe asthma exacerbations may be fatal.

- ICU admission : 10% of individuals for severe acute asthma

- Invasive mechanical ventilation:
  up to 1/3 of patients admitted to the ICU.

- Mortality rate : 27% in invasive mechanical ventilation

Introduction

Patients arriving in the emergency department for severe acute asthma—clinicians wonder

- accelerate the resolution of the dyspnea
- reduce the rate of hospitalization and ICU admission
- decrease the need for intubation and avoid its complications

Complications of invasive mechanical ventilation

Related to tube insertion
- Aspiration of gastric contents
- Trauma of teeth, pharynx, oesophagus, larynx, trachea
- Sinusitis (nasotracheal intubation)
- Need for sedation

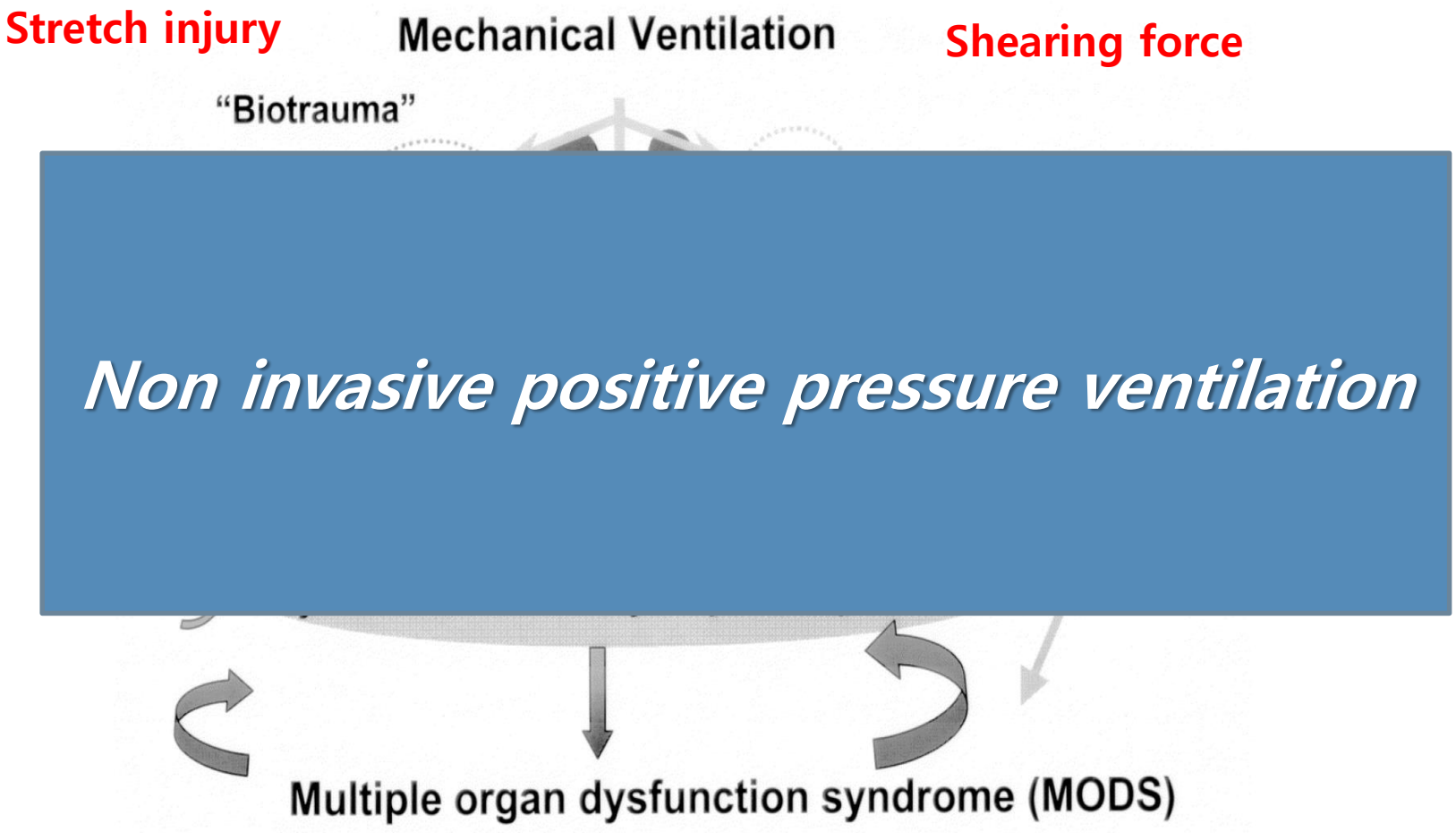
Related to mechanical ventilation
- Arrhythmias and hypotension
- Barotrauma

Related to tracheostomy
- Haemorrhage
- Trauma of trachea and oesophagus
- False lumen intubation
- Stomal infections and mediastinitis
- Tracheomalacia, tracheal stenoses and granulation tissue formation
- Tracheo-oesophageal or tracheoarterial fistulas

Caused by loss of airway defence mechanisms
- Airway colonisation with Gram-negative bacteria
- Pneumonia

Occurring after removal of the endotracheal tube
- Hoarseness, sore throat, cough and sputum
- Haemoptysis
- Vocal cord dysfunction and laryngeal swelling

Ventilator induced lung injury as a cause of multiple organ failure



Favorable Physiologic Effects of Noninvasive Positive Ventilation

Category	Major Experimental Findings on NIV
Work of breathing	Uniformly decreased inspiratory effort and WOB in patients with diverse etiologies and severity of pulmonary disease. Near-uniform decrease in dyspnea scores At maximum inspiratory support (15 cm H_2O), WOB and patient effort were reduced approximately 60%. Decreased mean diaphragmatic electromyogram 17%–93%. No difference in effectiveness between proportional-assist ventilation and pressure-support ventilation Some studies found improved endurance, inspiratory muscle strength, and spirometry after NIV. NIV settings that minimize WOB and patient effort are not necessarily the settings that maximize patient comfort.
Breathing pattern	Maximal inspiratory support that minimized inspiratory work load increased mean V_T 47%. Respiratory-frequency response to maximal NIV support differed in patients with COPD. Respiratory frequency typically decreased in patients with acute cardiogenic pulmonary edema.
Respiratory-system mechanics	NIV generally increased dynamic lung compliance 17%–50% in patients with COPD, morbid obesity, or restrictive chest-wall disease. During NIV, applied PEEP of 5 cm H_2O decreased dynamic intrinsic PEEP in patients with COPD. High (15 cm H_2O) inspiratory support without applied PEEP tends to increase inspiratory dynamic intrinsic PEEP in patients with COPD.
Cardiovascular function	In healthy subjects, nasal CPAP of $\geq$ 15 cm H_2O decreased cardiac output 20%–30%. In patients with stable COPD, high (10–20 cm H_2O) pressure-support with low (3–5 cm H_2O) PEEP decreased cardiac output approximately 20%. In patients with ALI those NIV levels had negligible effects on cardiac output. In patients with congestive heart failure, NIV often increased cardiac output by decreasing inspiratory effort and left-ventricular afterload.
Pulmonary gas-exchange function	At settings that minimized WOB, NIV typically increased pH an average 0.06, increased P_{aO_2} 8 mm Hg, and decreased P_{aCO_2} 9 mm Hg. NIV typically increased P_{aO_2} in patients with acute cardiogenic pulmonary edema, but only decreased P_{aCO_2} in the subgroup of patients with hypercapnia.

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Effectiveness and appropriate location for noninvasive positive pressure ventilation in acute respiratory failure from different causes

Cause of ARF	Level of evidence[#]	Location
AECOPD	A	Ward, RIICU, ICU Depending on severity
Weaning (AECOPD)	A	ICU, RIICU
CPE	A	ICU, RIICU
Immunocompromised patient	A	ICU, RIICU
Post-operative respiratory failure	B	ICU
Pre-intubation oxygenation	B	ICU
Endoscopy	B	Depending on severity
Asthma exacerbations	C	ICU, RIICU
ALI/ARDS	C	ICU
Extubation failure	C	ICU
Do-not-intubate status	C	Ward, RIICU
Pneumonia	C	ICU, RIICU

Is There a Rationale for Noninvasive Ventilation in Severe Acute Asthma?

- Despite several physiopathologic similarities to COPD exacerbation, there is a paucity of RCT data on NIV in severe acute asthma.

- Evidence for NIV in severe acute asthma was "controversial"

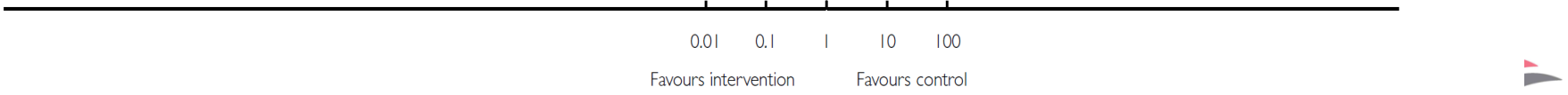
Randomized Controlled Trials on Noninvasive Ventilation in Severe Acute Asthma

Author	Method	Participant	Intervention	Outome
Soroksky 2003	RCT ER	15 NIV 15 control	NIV (BiPAP)	FEV1, intubation, hospital stay,Mortality
De Miranda 2004	RCT ER	42 NIV 21 control	CPAP	SpO2, RR, HR, PEF
Brandao 2009	Ranomized Non blinded ER	24 NIV 12 control	NIV (BiPAP)	FVC, FEV1, PEF, FEV 25-75% RR, HR, SpO2
Filho 2009	RCT ER	10 NIV 11 control	NIV (BiPAP)	RR, SpO2, TV, minute ventilation, IC, HR, BP
Gupta 2010	RCT ICU	28 NIV 25 control	NIV (BiPAP)	Hospital, ICU stay, Intubation, Mortality , FEV1

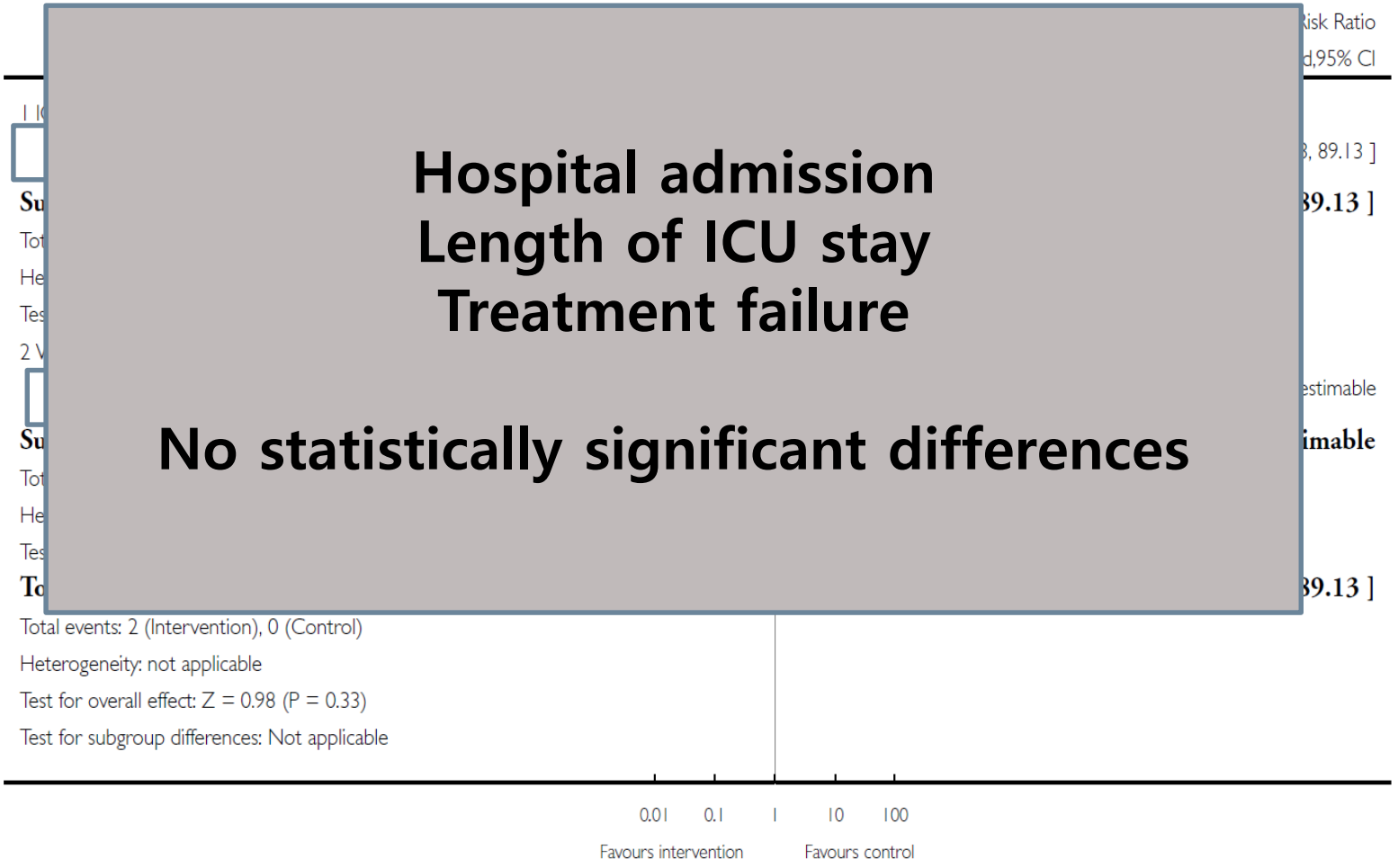
Cochrane review 2012

Outcome 1
Mortality during hospital admission.

Study or subgroup	Intervention n/N	Control n/N	Risk Ratio M-H,Fixed,95% CI	Weight	Risk Ratio M-H,Fixed,95% CI
1 ICU					
Gupta 2010	0/28	0/25			Not estimable
Subtotal (95% CI)	**28**	**25**			**Not estimable**
Total events: 0 (Intervention), 0 (Control)					
Heterogeneity: not applicable					
Test for overall effect: not applicable					
2 Ward					
Soroksky 2003	0/17	0/16			Not estimable
Subtotal (95% CI)	**17**	**16**			**Not estimable**
Total events: 0 (Intervention), 0 (Control)					
Heterogeneity: not applicable					
Test for overall effect: not applicable					
Total (95% CI)	**45**	**41**			**Not estimable**
Total events: 0 (Intervention), 0 (Control)					
Heterogeneity: not applicable					
Test for overall effect: not applicable					
Test for subgroup differences: Chi^2 = 0.0, df = -1 (P = 0.0), I^2 =0.0%					



Outcome 2
Endotracheal intubation



Spirometry and peak expiratory flow

- ***PEF***
- Soroksky 2003;DeMiranda 2004;Brandao 2009; Filho 2009

- ***FVC***
- Soroksky 2003; Brandao 2009; Filho 2009.

- ***FEV1***
- Soroksky 2003; Brandao 2009; Filho 2009; Gupta 2010).

significant improvement in the intervention group

2014 GINA guideline

The evidence regarding the role of NIV in asthma is weak.

A s 206

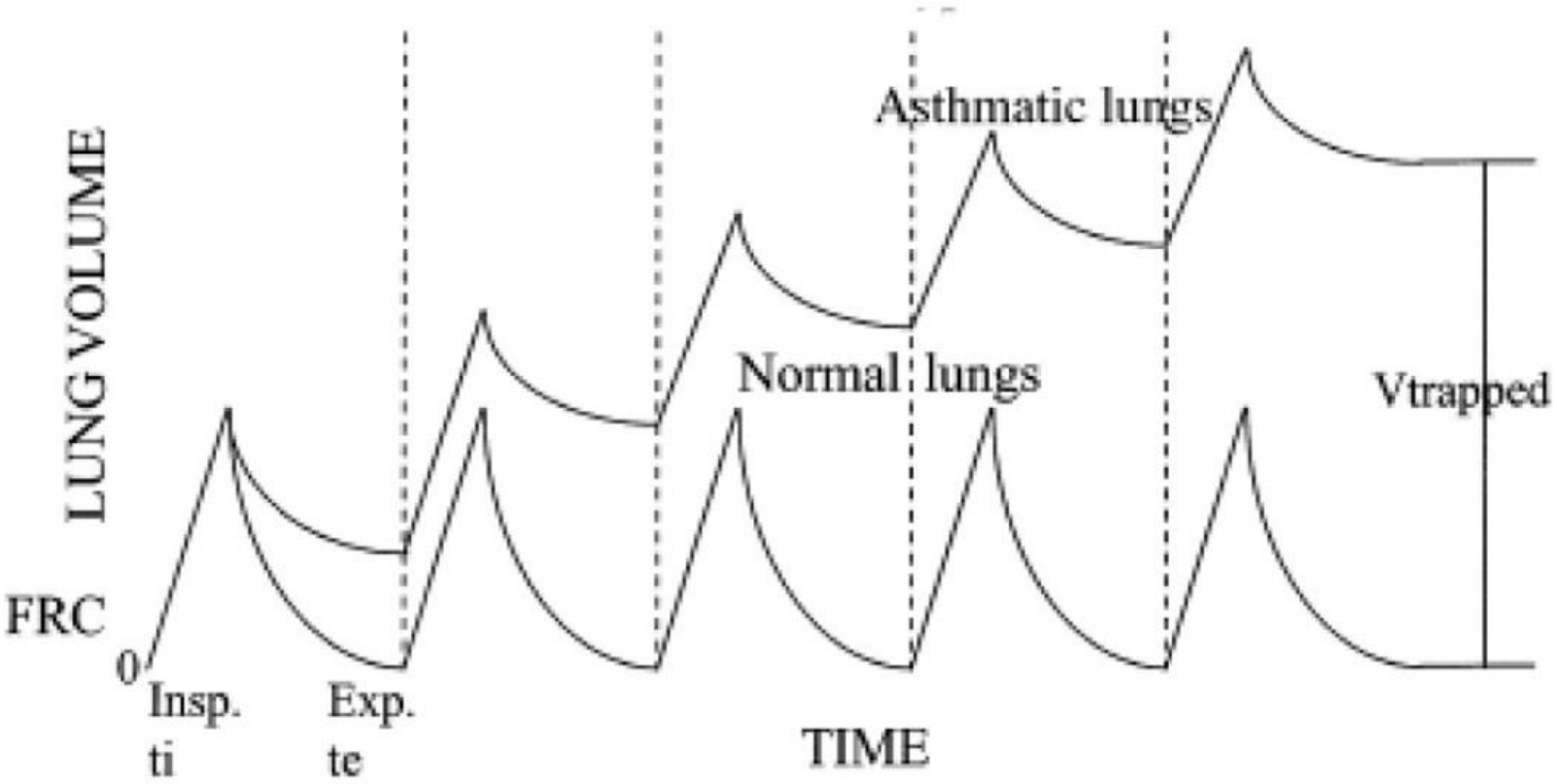
NIV

If N ely.

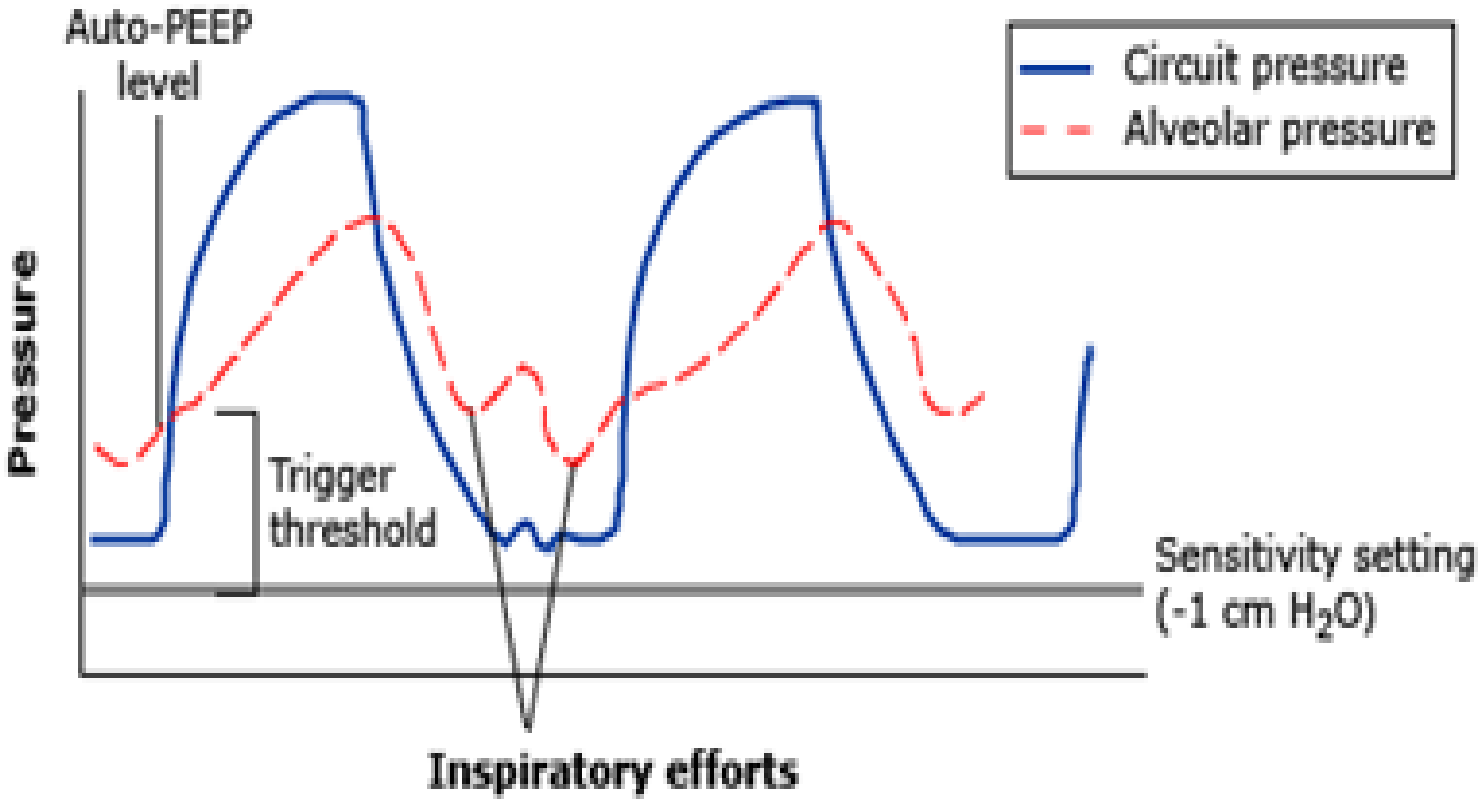
Why do we still not have a clear demonstration of the utility of NIV in severe acute asthma?

It should not be attempted in agitated patients, and patients should not be sedated in order to receive NIV

Intrinsic positive end expiratory pressure (=AutoPEEP) in obstructive airway disease



Trigger threshold for Auto PEEP



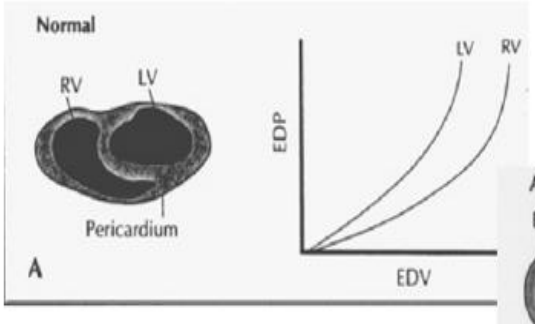
Systemic venous return ⇩

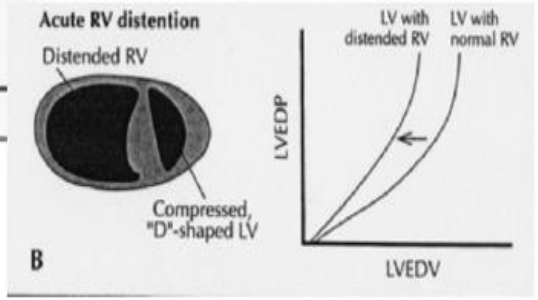
RV inflow ⇩

The two ventricles

pump *in series*

Pulmonary venous return ⇩





Left ventricular filling ⇩

LV compliance ⇩

RV volume ⇧

The two ventricles share common

fibers , septum and a common pericardium:

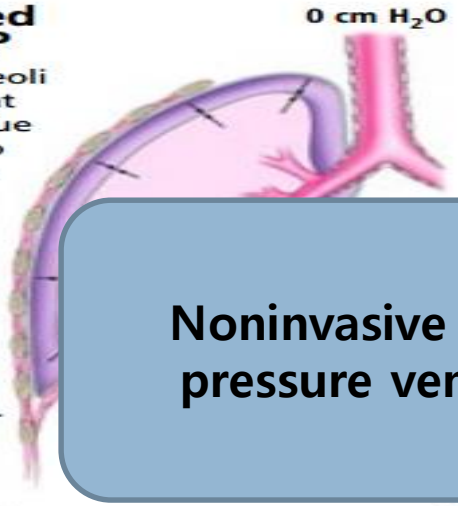
Ventricular interdependence

Cardiac output ↓

Treatment of Intrinsic PEEP (Auto-PEEP)

Air is trapped in auto-PEEP

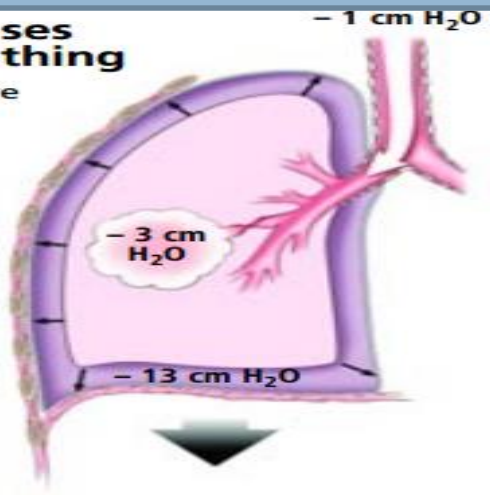
In auto-PEEP, alveoli remain inflated at end-expiration due to obstruction, so alveolar pressure is greater than atmospheric pressure. In the absence of inspiratory effort, intrapleural pressure approximates alveolar pressure.



Noninvasive positive pressure ventilation

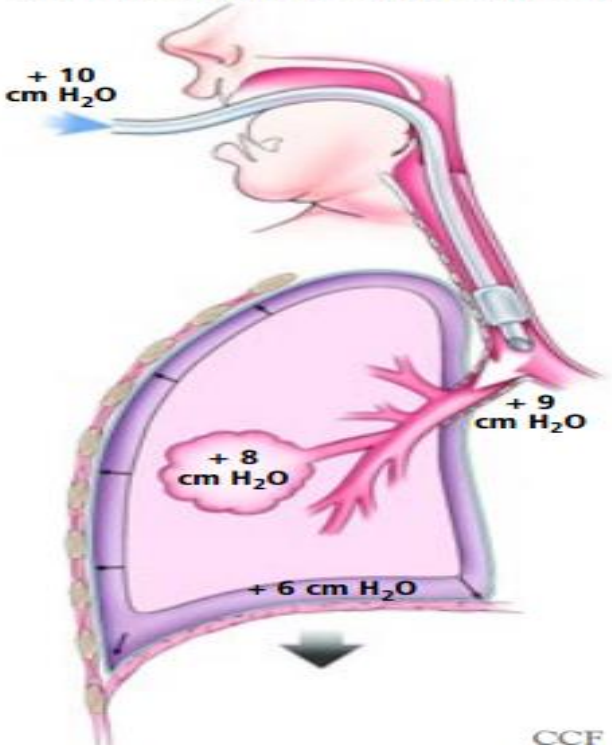
Auto-PEEP increases the work of breathing

To overcome the positive pressure in the alveoli during inspiration, the diaphragm must generate enough negative pressure to exceed the auto-PEEP and transmit negative pressure to the central airways, generating airflow.



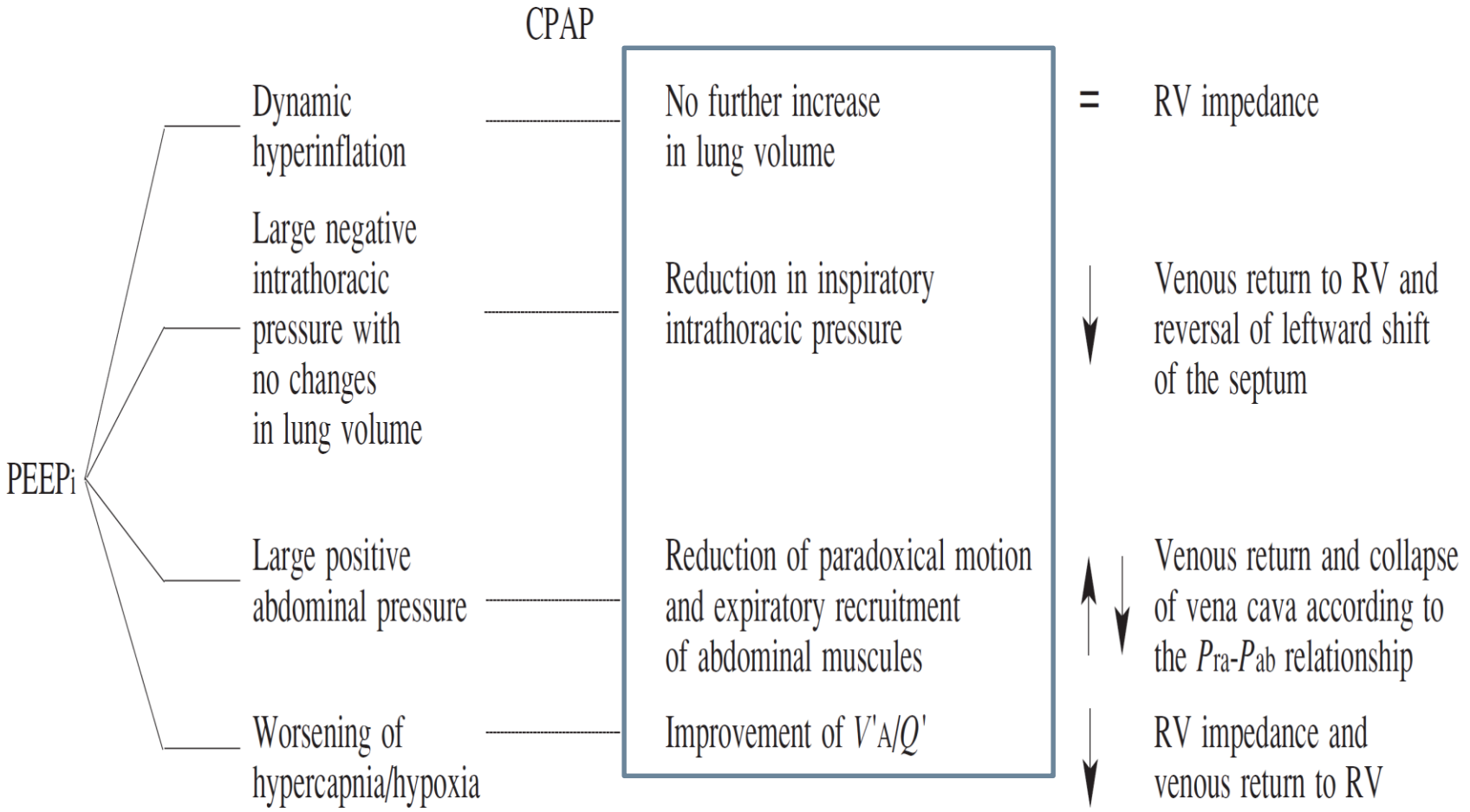
External PEEP treats auto-PEEP

The positive pressure of external PEEP eases the amount of work the diaphragm must do to draw air in, by allowing small negative deflections in intrapleural pressure to be sensed by the ventilator when the patient tries to trigger a breath.

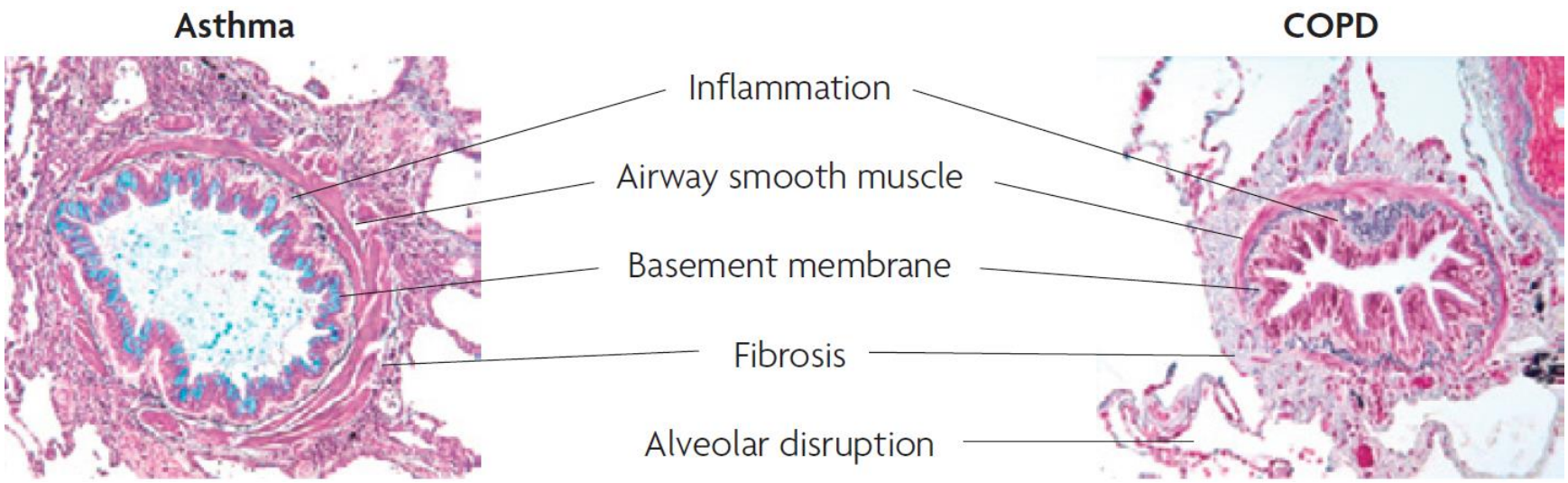


CCF

Theoretical effects of continuous positive airway pressure in COPD



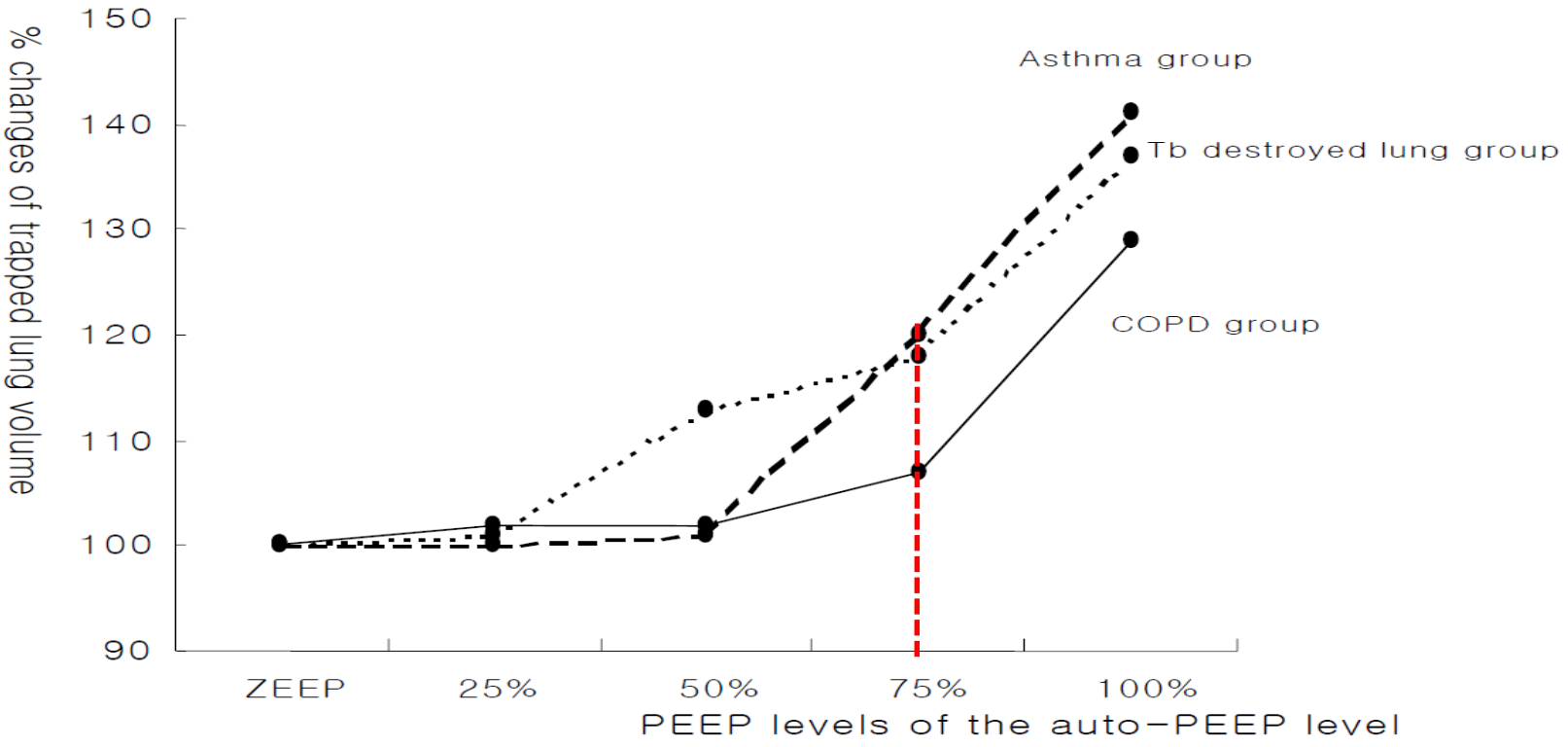
Difference between Asthma and COPD



Bronchial smooth m. contraction,
Airway inflammation
Increased secretion
-> reversible airway obstruction

Destruction of the lung parenchyme
loss of lung elastic recoil
-> dynamic hyperinflation

자가 호기말 양압(auto-PEEP)을 보인 환자에서 원인질환에 따른 PEEP적용 효과의 차이



Tuberculosis and Respiratory Diseases Vol. 57. No. 6, Dec, 2004

Possible risk of NIV in asthma

- inadvertent application of extrinsic PEEP

- The combination of relative hypovolemia and excessively applied extrinsic PEEP ->

  decreases venous return

  risk of haemodynamic compromise.

Possible risk of NIV in asthma

Asthma : reversible air way obstruction

->change of degree airway obstruction

->change of AutoPEEP

Time goal of NIV : ambiguous clinical characteristics of asthma exacerbation

- In the *COPD exacerbation,*

  th e of
  su
  th
  in te
  decompensations.

다음 중 한 가지에 해당될 때
• 호흡산증(pH≤7.35 또는 $PaCO_2$≥45 mmHg), 호흡보조근의 사용, 역설적 복근운동, 또는 늑간수축(함몰)이 관찰될 정도의 심한 호흡곤란

Time goal of NIV : ambiguous clinical characteristics of asthma exacerbation

An asthma attack is not characterized by marked arterial desaturation

Hypercapnia (10–26%) until very late in a life-threatening episode.

Normocapnia **(**compensatory hyperventilation): potentially evolving to pump failure.

Lung auscultation ?

Possible risk of NIV in asthma

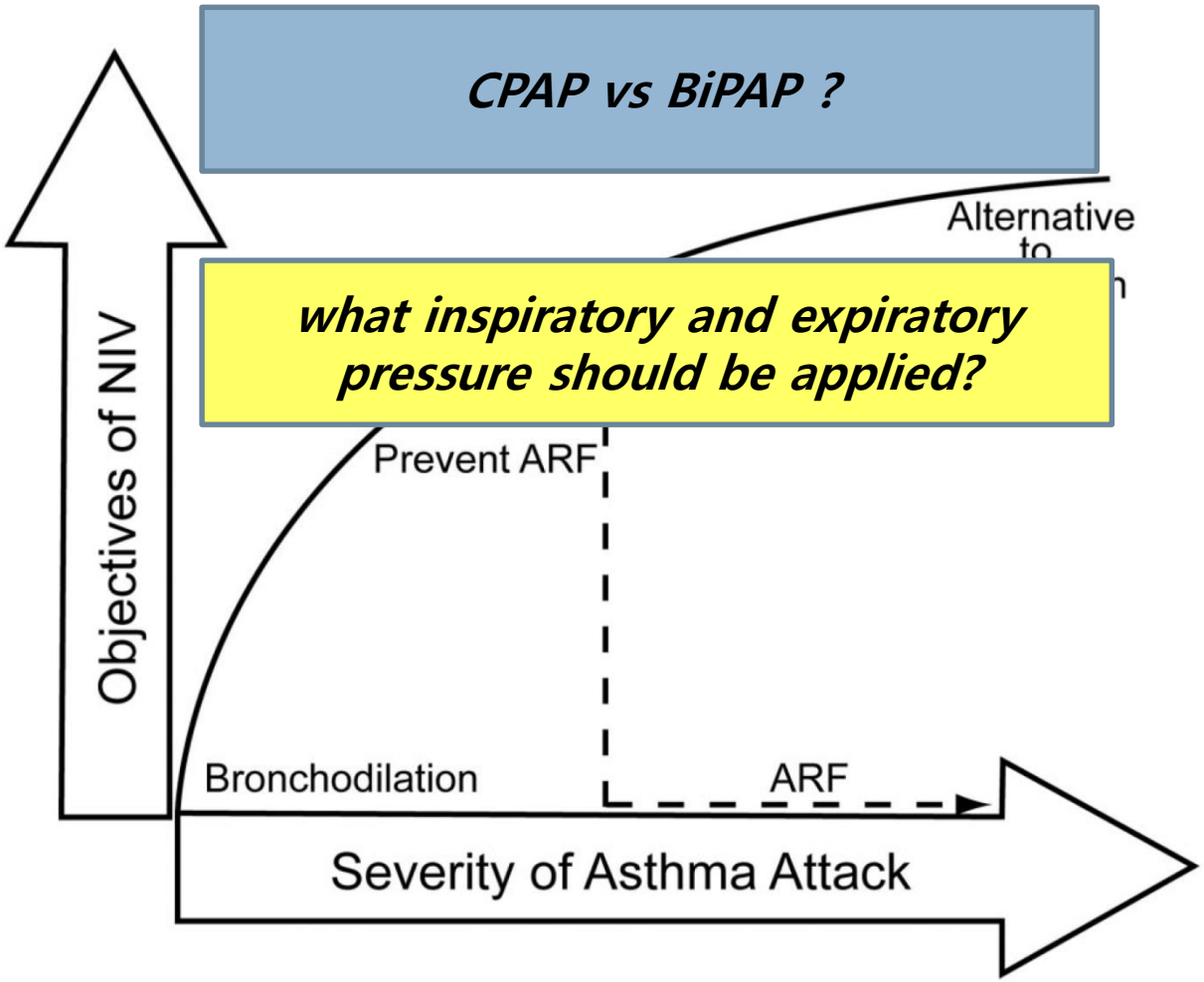
- Ambiguous clinical characteristics of severe asthma exacerbation:

  difficult decision –NIV

  a risk of delay in endotracheal intubation.

  Poor prognosis

Technical issues of NIV in severe acute asthma have not been clarified.



Asthma attack the patient may have difficulty coping with NIV

- Tachypnic and might struggle to coordinate their breathing with the NIV.
- Mucus production is a feature of severe acute asthma, and NIV can exacerbate sputum retention
- Bronchial hyper-reactivity may be increased by the high inspiratory flow and airway dryness associated with NIV.

Conclusions

- The exact role of NIV in this setting remains undefined, and no clinical guidelines have been published.

- More prolonged follow-up data and safety evaluation would be necessary.

Criteria for selecting severe asthmatic patients for NPPV trial

Tachypnea with respiratory rate >25 breaths·min^{-1}

Tachycardia with *f*C >110 breaths·min^{-1}

Use of accessory muscles of respiration

Hypoxia with a $P_{a,O_2}/F_{I,O_2}$ ratio >200 mmHg

Hypercapnia with P_{a,CO_2} <60 mmHg

FEV_1 <50% pred¶

Eur Respi Rev 2010;19:115,39-45