109 年機械通氣重症繼續教育課程(北區)

# NIPPV AND HFNC: EVIDENCE FOR LUNG AND NON-LUNG DISEASES

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109 年 7 月 12 日

# Outline

- **NIV: past , Present**
- Basic principles of ventilators :mode and setting
- Indications and patient s selection
- Choosing the interface
- Humidification and aerosol therapy in NIV
- Monitoring in acute NIV
- Patient-ventilator asychrony
- Complications of NIV
- Guideline introduction
- HFNC introduction

*Figure 2. Multitier iron lung used in poliomyelitis epidemics. Reproduced from Kacmarek (2011)* Respir Care; *56: 1170–1180 with permission from the publisher.*

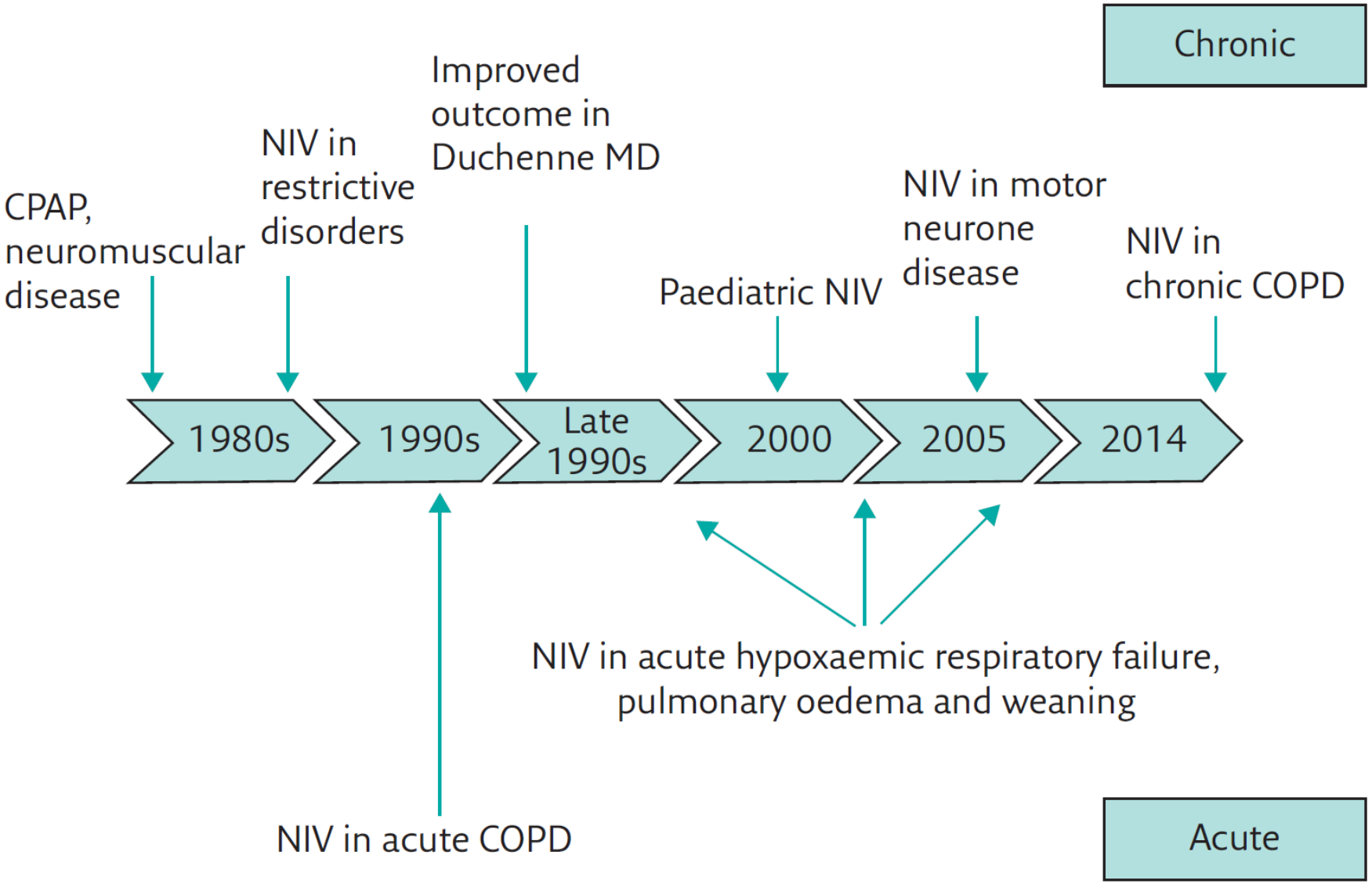



*Figure 3. Timeline of developments in NIV from the 1980s to the present day. MD: muscular dystrophy.*

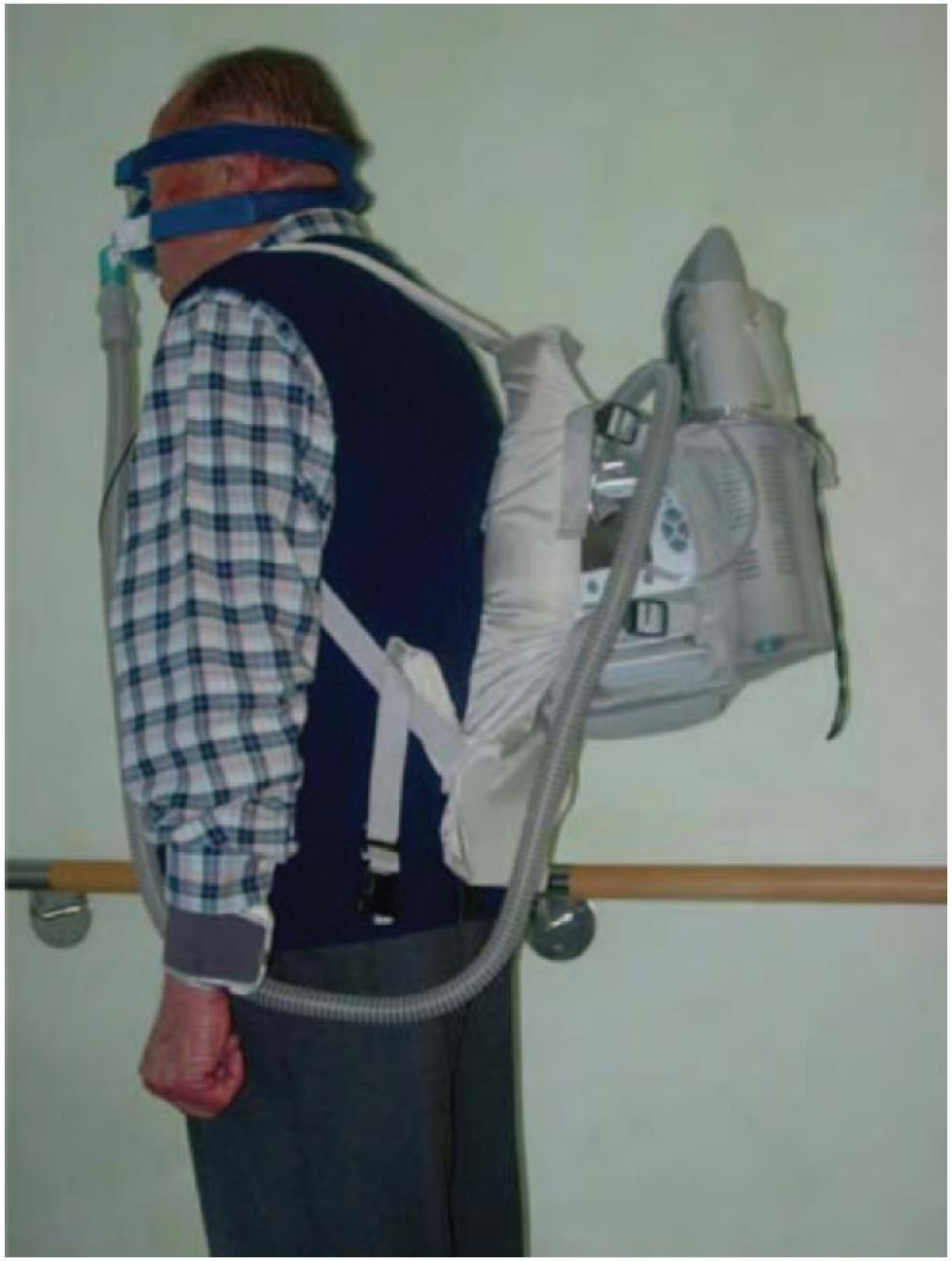


Fig. 1. A patient with COPD using noninvasive ventilation in addition to supplemental oxygen. (From Reference 51, with permission.)

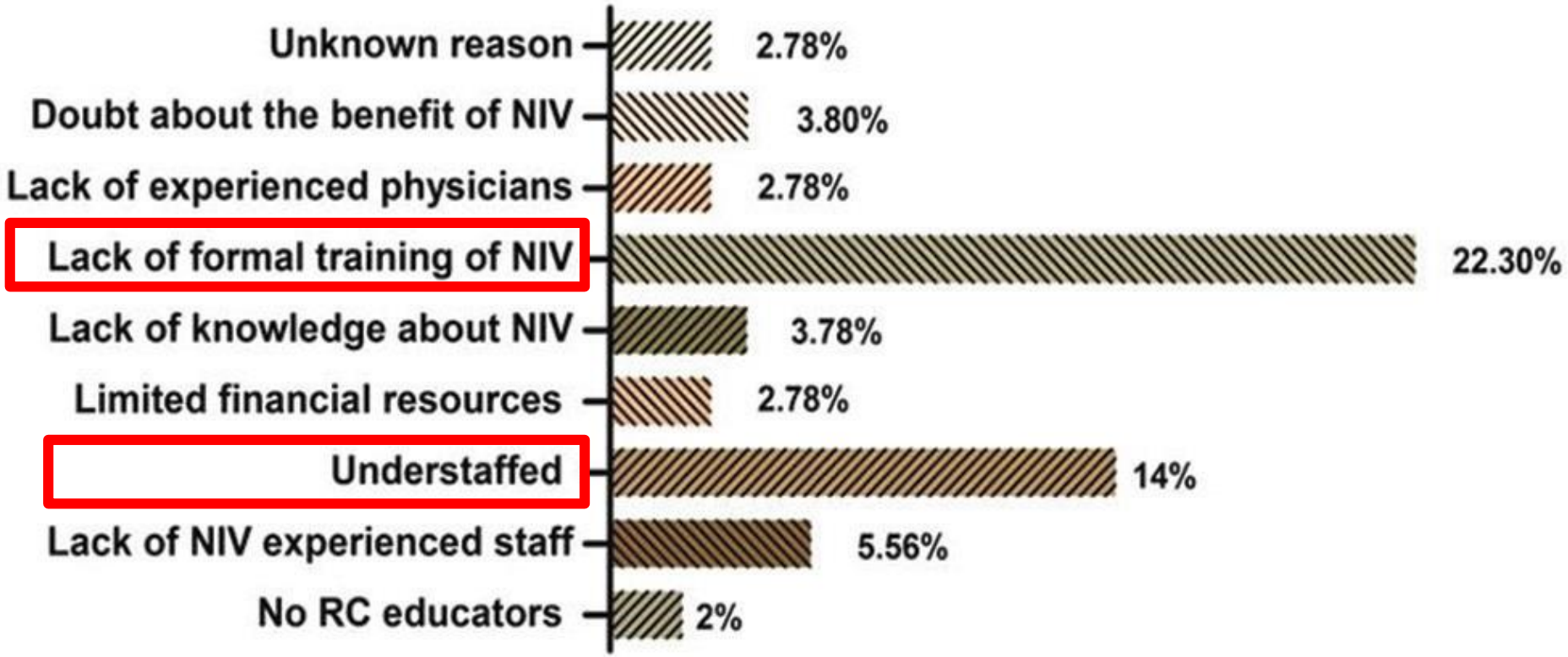
Respiration 2009;78(2):154-160.

## Noninvasive mechanical ventilation in acute respiratory failure: trends in use and outcomes

- 1997年至2011年期間急性呼吸衰竭需要通氣支持的重症患者的多中心數據庫研究(法國,14 ICU)
- 在3,163例患者中，1,232例（39%）接受了NIV。
- 第一線使用NIV從29%增加到42%，NIV成功率從69%增加到84%。
- 與第一線插管相比，第一線使用NIV有更好的60天存活率和更少的ICU院內感染。

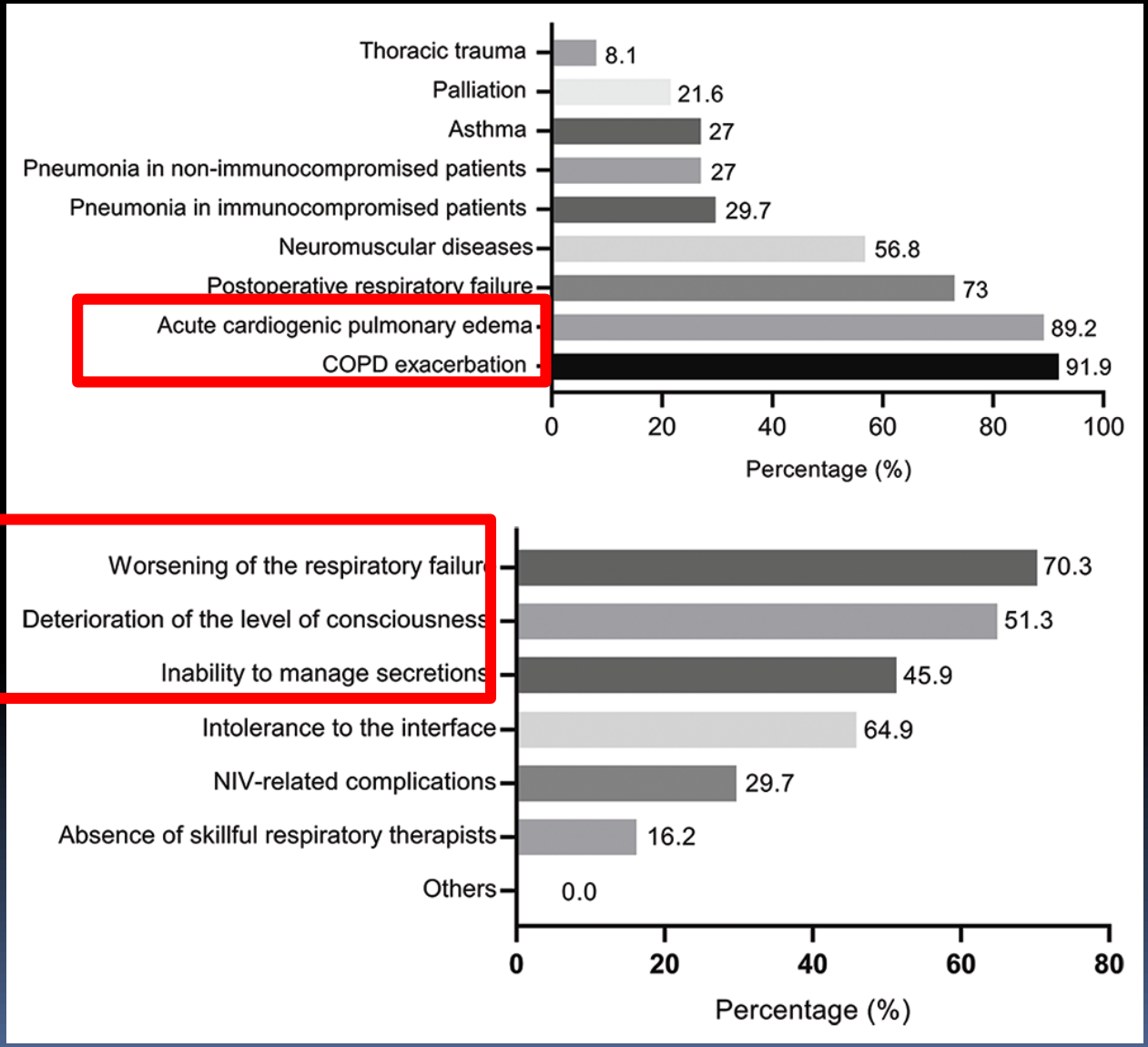
Intensive Care Med. 2014 Apr;40(4):582-91

# Underutilization of NIV




*Annals of Thoracic Medicine 2018; 13:237-242.*

# Indications and Failures of NIV




*Annals of Thoracic Medicine 2018; 13:237-242.*

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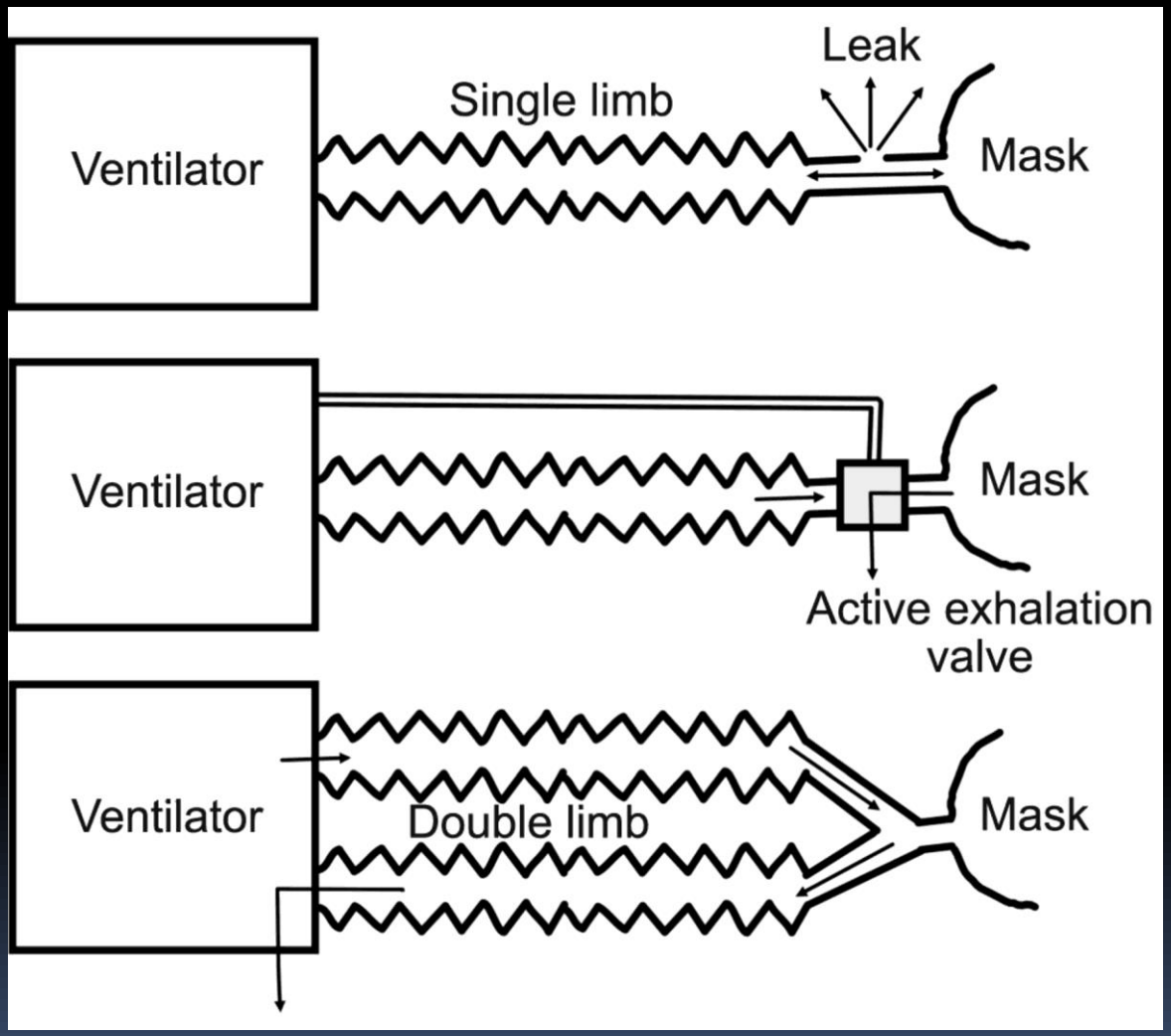
# Types of NIV

- **Negative pressure NIV**
  - Main means of NIV during the 1st half of the 20th century
  - Extensively used during polio epidemics
  - **Tank ventilator "iron lung"**
  - **Cuirass, Jacket ventilator,** Hayek oscillator
- **Positive pressure NIV**
  - Positive pressure delivered through mask
  - **CPAP & BiPAP**

# 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
- **Critical care ventilators**
  - Limited leak compensation

# Circuit configurations for noninvasive ventilation.




**Dean R Hess Respir Care 2013;58:950-972**

## Bilevel ventilators

## Critical care ventilators

**Table 2.** A comparison of ventilator designs for NIV.

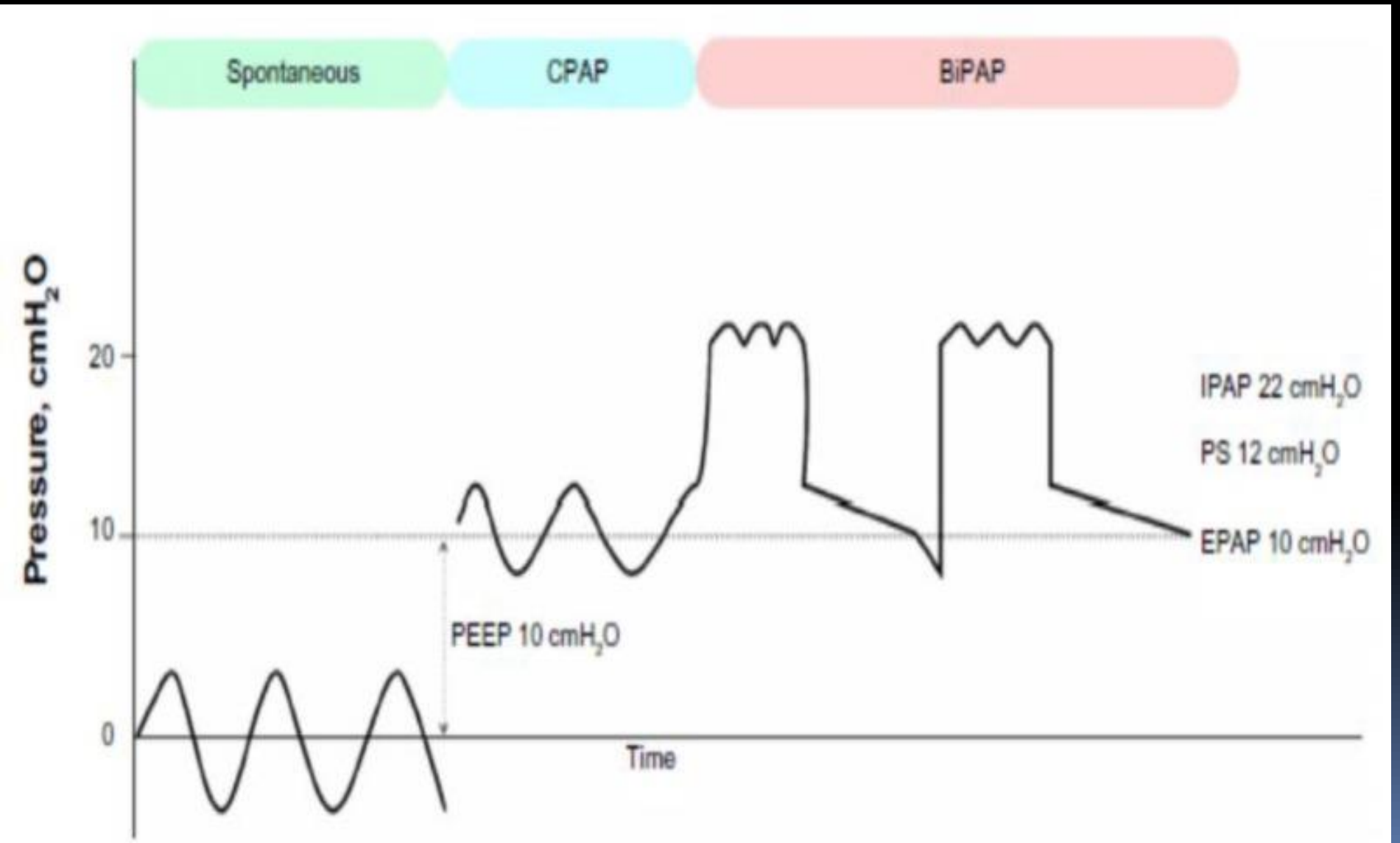
| Design | Description |
|---|---|
| Bilevel ventilator | Bilevel ventilators use internal blowers to generate flow through a single limb circuit during both inhalation and exhalation. A passive leak port, either in the circuit or the interface, is open throughout the respiratory cycle. An active exhalation valve is not needed because the exhaled gas passes through the leak port. |
| Intermediate ventilator | These ventilators are most commonly used for patient transport or home care ventilation. They utilize a single limb circuit with either an active exhalation valve near the patient or a passive leak port. In the past, these devices have been leak intolerant. However, newer designs offer leak compensation. |

| | |
|---|---|
| | compensation. |
| Critical care ventilator without NIV mode | In the past, critical care ventilators were designed primarily for invasive ventilation. As such, they were leak intolerant. Although these ventilators have been used for NIV, the absence of leak compensation often resulted in asynchrony and much clinician time and effort to minimize leak. |
| Critical care ventilator with NIV mode | Newer generation critical care ventilators have NIV modes, with dual limb circuits that separate the inspiratory from expiratory gases. NIV modes offer leak compensation, but the ability of the ventilator to compensate for leaks varies among manufacturers. Additional embellishments available from some manufactures include an adjustable flow termination and a maximum inspiratory time during pressure support, both of which improve synchrony with pressure support in the presence of leak. Some manufactures also provide leak compensation in all modes, including |

# Modes of NIV

- **Pressure modes**
  - Better tolerated than volume-cyded 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**

# Pressure/time curves in spontaneous, continuous positive airway pressure (CPAP) and BiPAP



# Ventilator Modes and Settings for NIV

- In an epidemiologic survey conducted in the US, over **90%** of NIV applications used bilevel type pressure-limited ventilators
- only 5% used critical care ventilators.

*Chest 2014: 145(5): 964-971.*

# Continuous positive airway pressure (CPAP)

- a single selected pressure applied via a noninvasive interface to the upper airway.
- mainly for cardiogenic pulmonary edema or prophylactically for postoperative patients.
- disadvantage of CPAP is that it provides **no active respiratory assistance** during inspiration

# Bilevel positive airway pressure (bilevel NIV)

- consists of a higher inspiratory pressure (IPAP) and lower expiratory pressure (EPAP).
- as **higher EPAP is used to improve oxygenation** and higher pressure support to increase tidal volume and reduce dyspnea.

# Pressure support ventilation (PSV)

- similar to bilevel NIV but is provided on **critical care ventilators** or a few dedicated NIV ventilators.
- Ventilator settings in PSV are essentially the same as with bilevel NIV
- terminology is different; EPAP equals PEEP, but **IPAP equals pressure support plus PEEP**.

# Pressure Control Ventilation (PCV)

- flow triggered and uses preset inspiratory and expiratory pressures
- PCV is the same as with PSV, but **inspiratory time is set** using absolute time or an I:E ratio.
- improve expiratory synchrony when inspiratory pressure is prolonged in the face of **air leaks**
- or a delayed drop in inspiratory flow as may be seen in COPD patients.
-

# Average Volume Assured Pressure Support (AVAPS)

- automatically adjust **inspiratory airway** pressure to achieve a target tidal volume.
- sets a target tidal volume, range of inspiratory pressures, EPAP and a backup rate

# Volume-targeted modes

- set tidal volumes of 6 - 8 mL/kg PBW.
- **inability to compensate for leaks**
- possible **auto-cycling** as the persisting leak triggers **premature breaths.**

# Considerations in the Selection of a Ventilator for Noninvasive Ventilation

| |
|---|
| Leak compensation |
| Trigger and cycle coupled to patient's breathing pattern |
| Rebreathing |
| Oxygen delivery (acute care) |
| Monitoring |
| Alarms (safety vs nuisance) |
| Portability (size, weight, battery) |
| Tamper-proof |
| Cost |

(Data from reference 114.)

Respir Care 2012;**57**(6):900-918; discussion 918-920

## Protocol for initiation of noninvasive positive pressure ventilation

| |
|---|
| 1. Appropriately monitored location, oximetry, respiratory impedance, vital signs as clinically indicated |
| 2. Patient in bed or chair at >30-degree angle |
| 3. Select and fit interface |
| 4. Select ventilator |
| 5. Apply headgear; avoid excessive strap tension (one or two fingers under strap) |
| 6. Connect interface to ventilator tubing and turn on ventilator |
| 7. Start with low pressure in spontaneously triggered mode with backup rate; pressure limited: 8 to 12 $cmH_2O$ inspiratory pressure; 3 to 5 $cmH_2O$ expiratory pressure |
| 8. Gradually increase inspiratory pressure (10 to 20 $cmH_2O$) as tolerated to achieve alleviation of dyspnea, decreased respiratory rate, increased tidal volume (if being monitored), and good patient–ventilator synchrony |
| 9. Provide $O_2$ supplementation as needed to keep $O_2$ saturation >90 percent |
| 10. Check for air leaks, readjust straps as needed |
| 11. Add humidifier as indicated |
| 12. Consider mild sedation (eg, intravenously administered lorazepam 0.5 mg) in agitated patients |
| 13. Encouragement, reassurance, and frequent checks and adjustments as needed |
| 14. Monitor occasional blood gases (within 1 to 2 hours) and then as needed |

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# Indications for NIV

## Acute NIV

- COPD Exacerbation
- Cardiogenic Pulmonary Edema
- Weaning ventilator and Post-Extubation
- Immunocompromised Patients
- ARDS
- Acute Asthma
- Community-Acquired Pneumonia
- Palliative care and at the end of life
- Pre-oxygenation Before Intubation
- Post-Operative Respiratory Failure
- Obesity Hypoventilation Syndrome
- Bronchoscopy

## Long term NIV

- Neuromuscular disorders
- Sleep apnea
- Motor neurone disease/ALS
- Chest wall disorders
- Chronic COPD

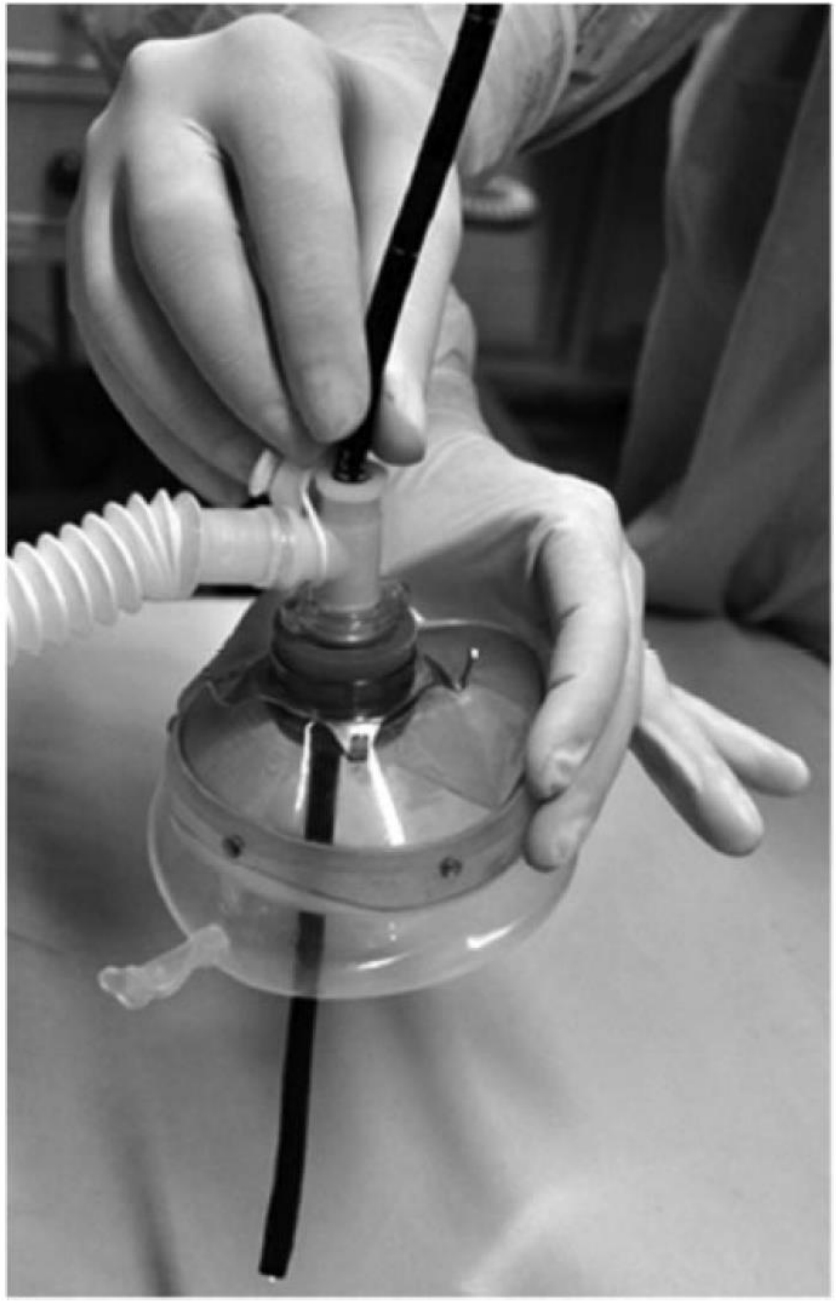

Fig. 2. Bronchoscope inserted through the swivel adaptor of a face mask for noninvasive ventilation. (From Reference 88.)

Respir Care 2012;**57**(11):1927-1936

# Contraindications of NIV

- Coma, seizures, or severe central neurologic disturbances**( 例外:hypercapnic encephalopathy)**
- Inability to protect the airway or clear respiratory secretions
- Unstable hemodynamic conditions (blood pressure or rhythm instability)
- Upper airway obstruction
- Severe upper gastrointestinal bleeding
- Recent facial surgery, trauma, burns, deformity, or inability to fit the interface
- Recent gastroesophageal surgery
- Undrained pneumothorax
- Recurrent vomiting

Crit Care Clin. 2018 Jul;34(3):395-412

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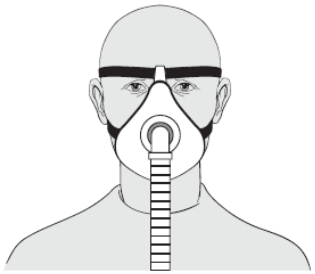
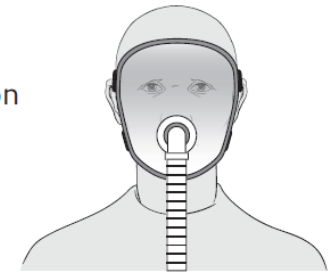


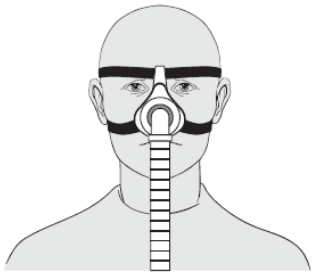
**Oronasal mask#**

Covers mouth and nose
Special subtype: hybrid masks (a combination of nasal pillows and an oral mask)
With or without forehead spacer



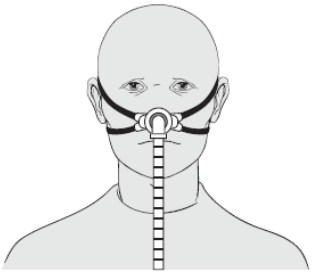
**Full face mask#**

Also called total face mask, cephalic or integral mask
Covers mouth, nose and eyes and seals around the perimeter of the face



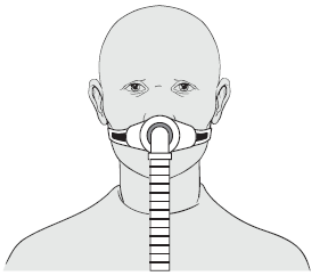
**Nasal mask#**

Covers the whole nose but not the mouth
With or without forehead spacer



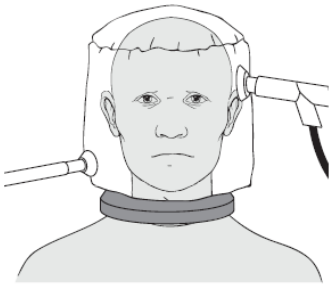
**Nasal pillows**

Subtype of nasal mask, also nasal plugs or nasal slings
Applied externally to the nares



**Oral masks and mouthpieces**

Placed between the patient's lips
Mouthpieces have various degrees of flexion and are held in place by a lip seal or the teeth
Oral masks can also have headgear as a securing system



**Helmet**

Transparent hood with collar
Covers the whole head and all or part of the neck, no contact with the head
Has at least two ports
Most helmets have an anti-asphyxia valve

*Figure 1. The six main interface types for NIV. #: available as a vented or non-vented version. Image of the human head by Patrick J. Lynch reproduced from Wikimedia Commons under CC BY 2.5 licence.*

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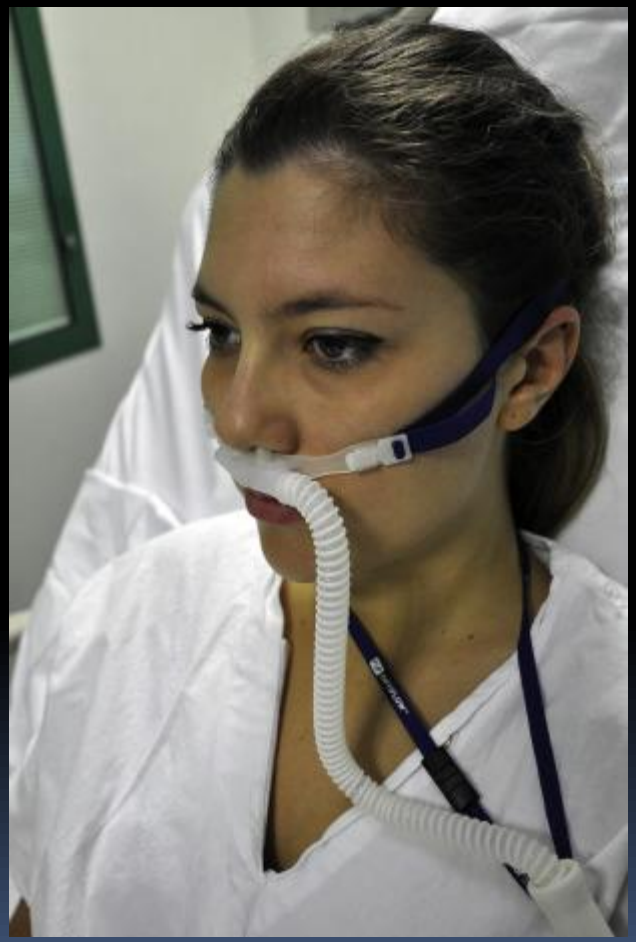
**Edited by Anita K. Simonds 2015**

HFNCO



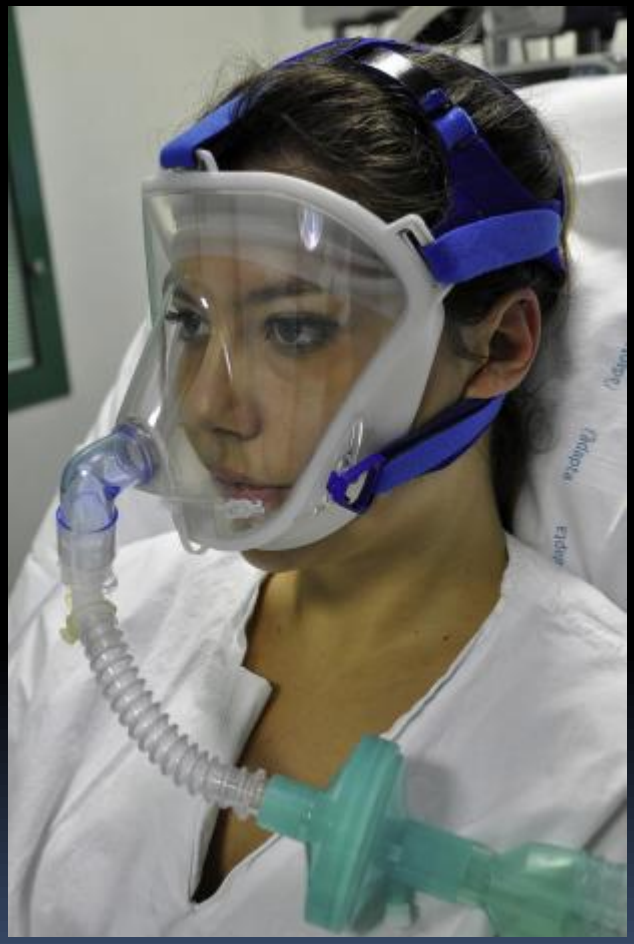
Nasal mask

**Oronasal Mask**

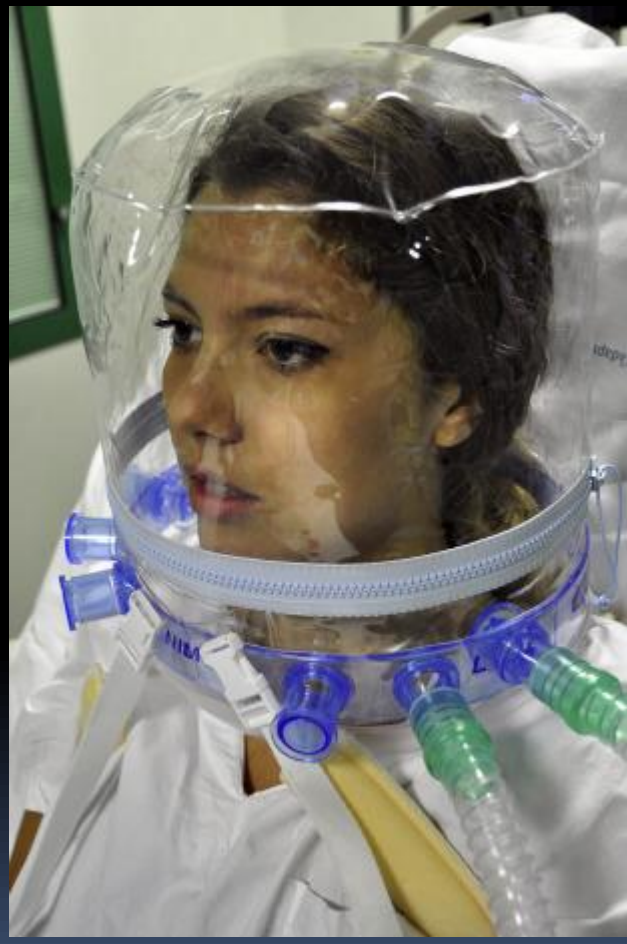
Crit Care Clin. 2018 Jul;34(3):395-412

Nasogastric tube positioned through the oronasal mask

Full-face mask.



Helmet



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# Oronasal VS nasal mask

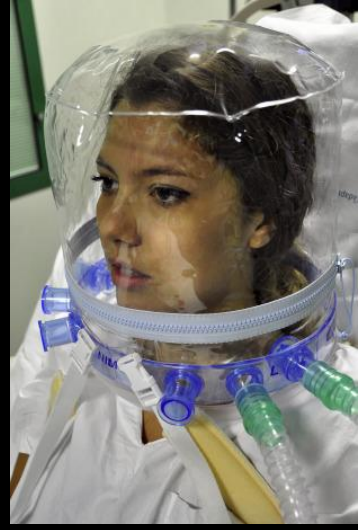
- 口鼻面罩應該是高碳酸血性急性呼吸衰竭初始治療的第一線策略（鼻罩組氣漏較大）
  ----- Girault，Crit Care Med2009; 37（1）：124-131
- 鼻面罩的耐受性低於口鼻面罩
  ----- Kwok H，Crit Care Med2003; 31（2）：468-473。
- COPD急性發作使用口鼻面罩的呼吸速率有較大的下降，其他沒有差異。
  ----- Anton A，Respir Care2003; 48（10）：922-925。

- 通過口腔洩漏常見於鼻罩。 這會影響舒適度，導致口乾和通氣效率降低，影響patient-ventilator interaction (trigger and cycle) ，擾亂睡眠結構
  ----- Respir Care2011; 56 (2) : 153-165
- 吸入性肺炎是口鼻面罩的可能風險，但這種情況較少見
  ------ Eur Respir J 2004; 23 (4) : 605-609

# Oronasal mask VS Total face mask

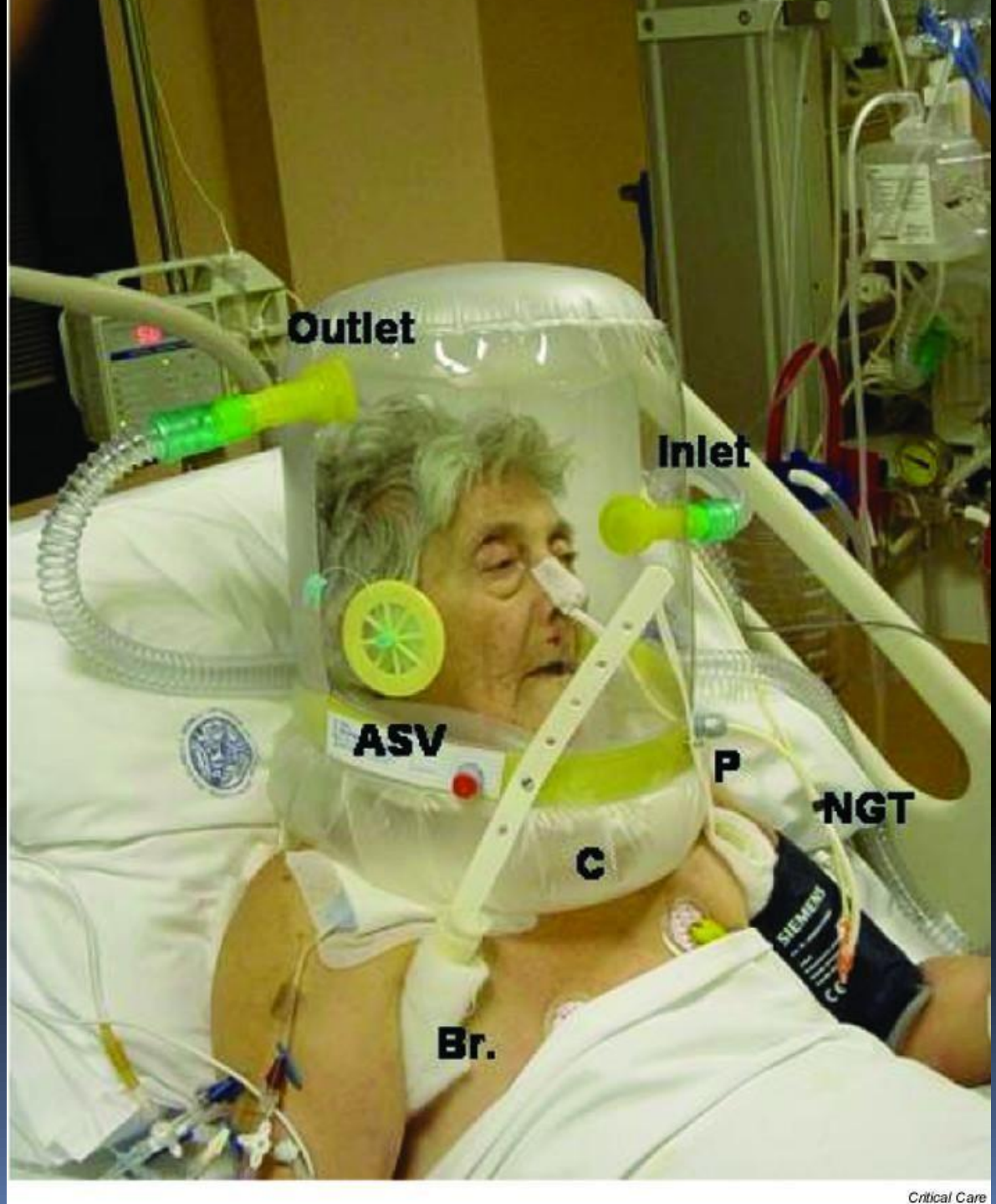
- total face mask was more comfortable than the oronasal mask and suggested that the total face mask should be available as an option in units where NIV is routinely applied ----- Respiration2011;**82**(5):426-430.
- total face mask avoided pain on the bridge of the nose and presented no air leaks around the eyes and mouth ---- J Bras Pneumol2009;**35**(2):164-173.

# Helmit



- Helmit有一個透明的罩子和柔軟的邊緣，密封在頸部.頭盔有兩個端口，一個通過氣體進入，另一個通過氣體排出，並通過腋帶固定在患者身上。美國食品和藥物管理局尚未認可任何可用頭盔，但它們已在其他一些國家獲得批准，並且在歐洲和南美洲的某些地方很受歡迎

Respir Care 2009;54(1):71-84




Critical Care

*Critical Care* 20049:98

- 應用NIV治療急性呼吸衰竭，界面的首選應該是**口鼻面罩**。
- 現有證據表明，**全面罩**可能也是合理首選。
- 如果患者不能忍受口鼻面罩或全面罩，或者出現面部皮膚破裂等併發症，則應提供其他介面。
- 美國和歐洲的調查結果表明，臨床醫生最常使用**口鼻面罩**治療急性呼吸衰竭患者

Respir Care 2009;**54**(10):1306-1312
Eur Respir J 2010;**36**(2):362-369.

# Advantages and Disadvantages of Various Interfaces for NIV

| Interface | Advantages | Disadvantages |
|---|---|---|
| Nasal mask | Less risk for aspiration<br>Easier secretion clearance<br>Less claustrophobia<br>Easier speech<br>May be able to eat<br>Easy to fit and secure<br>Less dead space | Mouth leak<br>Higher resistance through nasal passages<br>Less effective with nasal obstruction<br>Nasal irritation and rhinorrhea<br>Mouth dryness |
| Oronasal mask | Better oral leak control<br>More effective in mouth breathers | Increased dead space<br>Claustrophobia<br>Increased aspiration risk<br>Increased difficulty speaking and eating<br>Asphyxiation with ventilator malfunction |
| Mouthpiece | Less interference with speech<br>Very little dead space<br>May not require headgear | Less effective if patient cannot maintain mouth seal<br>Usually requires nasal or oronasal interface at night<br>Potential for orthodontic injury |
| Total face mask | May be more comfortable for some patients<br>Easier to fit (one size fits all)<br>Less facial skin breakdown | Potentially greater dead space<br>Potential for drying of the eyes<br>Cannot deliver aerosolized medications |
| Nasal pillows | Advantages of nasal mask, but more comfortable<br>Less risk of facial skin breakdown than nasal mask | Same as nasal mask |

Respir Care 2012;57(6):900–918.

*Table 2. Comparison of oronasal[#] and nasal masks*

| Aspect | Oronasal mask | Nasal mask |
|---|---|---|
| **Mouth leak** | No | Yes |
| **Mouth breathing** | Possible | Decreases NIV quality |
| **Dead space** | Higher | Low |
| **First choice interface** | Acute care | Chronic care |
| **Communication** | Reduced | Possible |
| **Eating and drinking** | No | Possible |
| **Expectoration** | No | Possible |
| **Risk of aspiration** | Elevated | Reduced |
| **Risk of aerophagia** | Elevated | Reduced |
| **Claustrophobia** | Elevated | Reduced |
| **Comfort** | Lower | Higher |

[#]: sometimes also known as facial or face masks. Reproduced and modified from Storre *et al.* (2008), with permission from the publisher.

*Table 2. Characteristics of the different interfaces*

| | Oronasal mask | Total face mask | Helmet | Nasal mask | Nasal prongs | Mouth pieces |
|---|---|---|---|---|---|---|
| Acute setting | ● | ● | ● | ○ | ○ | ○ |
| Use outside HDU/ICU | ● | ● | | ● | ● | ● |
| Chronic setting | ● | ● | | ● | ● | ● |
| Less claustrophobic | | ○ | ○ | ● | ● | ● |
| More likely to have leaks in the acute setting | ● | | | ● | ● | ● |
| Nasal patency required | | | | ● | ● | |
| Coughing and expectoration is easier | | | | ● | ● | |
| Useful for prominent facial anatomy | | ● | ● | | ● | ● |
| High level of noise | | | ● | | | |
| No pressure on the nasal bridge | | ● | ● | | ● | ● |
| High gas flow required | | | ● | | | |
| Chance of eye irritation | ● | ○ | ○ | ● | | |
| Speaking is easier | | | ● | ● | ● | |

HDU: high-dependency unit; closed circles: applicable to the interface; open circles: an alternative, but less common or less frequent option. Reproduced and modified from Brill (2014) with permission from the publisher.

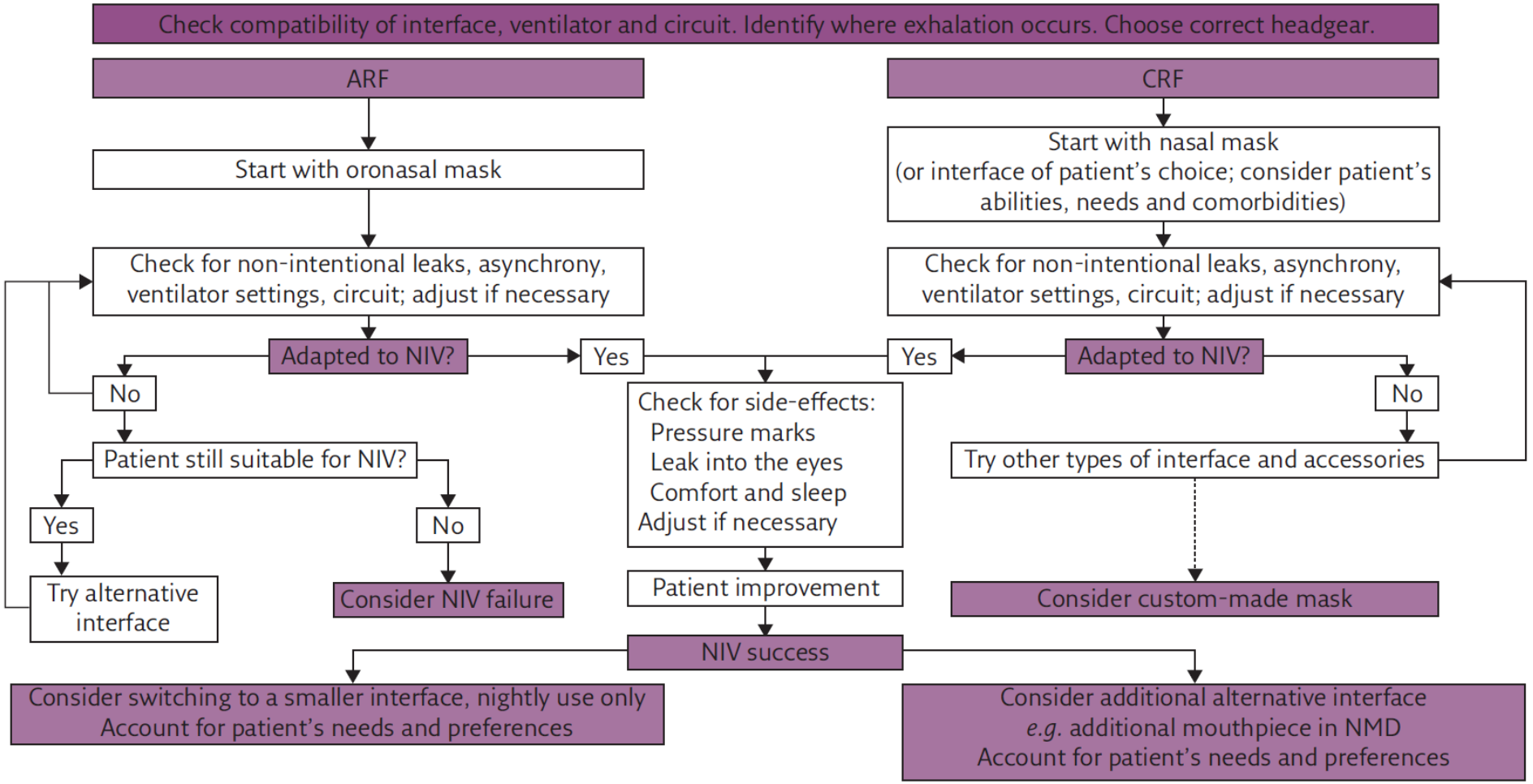



*Figure 2. Interface strategies for NIV in adult patients with ARF and chronic respiratory failure (CRF). NMD: neuromuscular disease.*

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# Humidification

- 在nasal mask的口腔洩漏的情況下，單向氣體流動會干燥上呼吸道並增加鼻氣道阻力。
- 上呼吸道乾燥會導致不適並可能影響NIV的耐受性.
- 加濕水平不需要與插管患者一樣大；在約30℃下100%的相對濕度通常是足夠的
- 不推薦使用heat and moisture exchanger與NIV一起使用，因為額外的死腔會減少二氧化碳的排除，特別是對於高碳酸血症患者

Respir Care2010;55(2):209-216

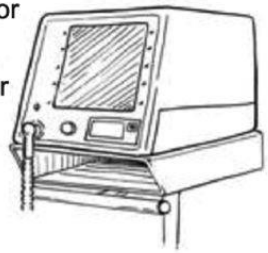
# Inhaled aerosol therapy

- 接受NIV的阻塞性肺病患者可受益於吸入性支氣管擴張劑治療
- Aerosol therapy可以通過pressurized metered-dose inhaler with a spacer or nebulizer有效地傳遞.
- 患者也可以中斷NIV ，並以常規方式給予吸入藥物

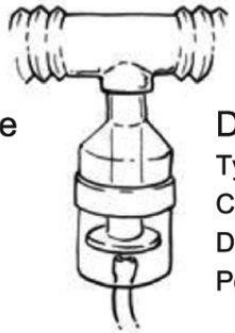
Respir Care 2013;58(2):241-249

# Factors influencing aerosol delivery during noninvasive ventilation (NIV). pMDI = pressurized metered-dose inhaler.

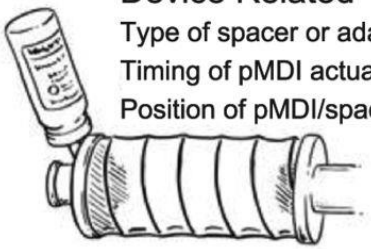
**Ventilator Related**
Critical care ventilator
NIV ventilator
Home care ventilator



**Circuit Related**
Type of circuit
Position of leak port
Inhaled gas humidity
Inhaled gas density



**Device Related - pMDI**
Type of spacer or adapter used
Timing of pMDI actuation
Position of pMDI/spacer

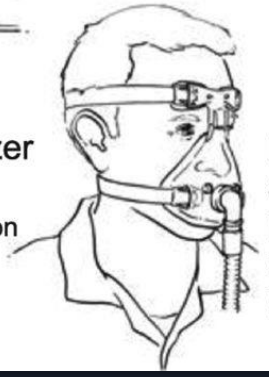


**Drug Related**
Dose
Aerosol particle size
Duration of action

**Breathing Parameters**
Mode of ventilation
Tidal volume
Breathing frequency
Inspiratory air flow
Pressure settings

**Type of Interface**
Face mask
Nasal cannula

**Device Related - Nebulizer**
Type of nebulizer used
Continuous/intermittent operation
Duration of nebulization
Position in the circuit



**Patient Related**
Severity of airway obstruction
Mechanism of airway obstruction
Presence of intrinsic PEEP
Patient-ventilator synchrony

Dean R Hess Respir Care 2013;58:950-972

# Outline

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# Risk Factors for Noninvasive Ventilation Failure

Acute hypercapnic respiratory failure
- Poor neurologic score: Glasgow Coma Score $< 11$
- Tachypnea: $> 35$ breaths/min
- pH $< 7.25$
- Acute Physiology and Chronic Health Evaluation score $> 29$
- Asynchronous breathing
- Edentulous
- Excessive air leak
- Agitation
- Excessive secretions
- Poor tolerance
- Poor adherence to therapy
- No initial improvement within first 2 h of noninvasive ventilation
- No improvement in pH
- Persistent tachypnea
- Persistent hypercapnia

Acute hypoxemic respiratory failure
- Diagnosis of ARDS or pneumonia
- Age $> 40$ y
- Hypotension: systolic blood pressure $< 90$ mm Hg
- Metabolic acidosis: pH $< 7.25$
- Low $P_{aO_2}/F_{IO_2}$
- Simplified Acute Physiology Score II $> 34$
- Failure to improve oxygenation within first hour of noninvasive ventilation: $P_{aO_2}/F_{IO_2} > 175$ mm Hg

(Data from reference 99.)

Dean R Hess Respir Care 2013;58:950-972

## Acute NIV monitoring

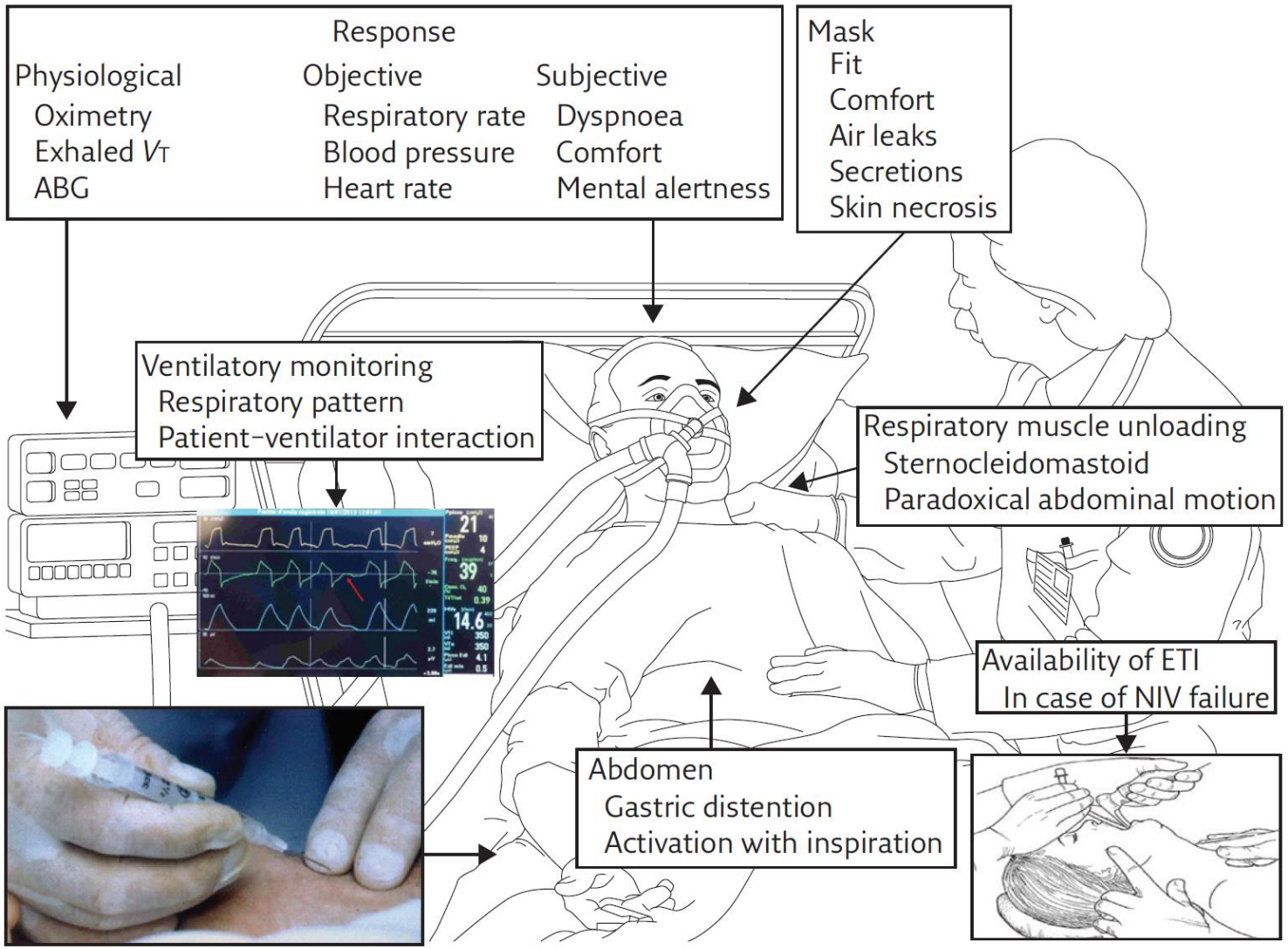


*Figure 1. Key points for monitoring of patients undergoing NIV for ARF. ABG: arterial blood gas. Reproduced and modified from Umberto Meduri (1996)* Clin Chest Med; *17: 513–553, with permission from the publisher.*

# Monitoring of NIV

- . Level of consciousness
- . Comfort
- . Chest wall motion
- . Accessory muscle recruitment
- . Patient-ventilator synchrony
- . Respiratory rate
- . Exhaled tidal volume
- . Flow and pressure waveforms
- . Heart rate
- . Blood pressure
- . Continuous electrocardiography
- . Continuous oximetry
- **. Arterial blood gas at baseline, after 1 hour to 2 hours, and as clinically indicated**

Crit Care Clin. 2018 Jul;34(3):395-412

# Criteria used to perform ETI

- . Patient intolerance
- . Inability to improve gas exchange
- . Inability to improve dyspnea or respiratory muscle fatigue
- . Appearance of severe hemodynamic or electrocardiographic instability
- . Severe neurologic deterioration

Crit Care Clin. 2018 Jul;34(3):395-412

# Optimal location for NIV

- 需要考慮患者的監測需求
- 單位的監測能力
- 可用的技術和人力資源（護理和呼吸治療）
- 照護者的技能和經驗

- 在許多醫院，NIV在急診室開始，之後患者被轉到ICU。
- 由於ICU床位非常昂貴，許多醫院在普通病房治療NIV的患者。
- 如果病房醫護人員接受了足夠的技術培訓，並且在24小時內都有人支援，通過適當的監測，穩定的患者可在病房照護。
- NIV病人的理想照護位置因國家和醫院而異，具體取決於當地因素。

Eur Respir J2002;**19**(6):1159-1166

# Noninvasive Ventilation Outside the Intensive Care Unit From the Patient Point of View: A Pilot Study

Luca Cabrini MD, Elena Moizo MD, Elisa Nicelli MD, Gloria Licini MD, Stefano Turi MD, Giovanni Landoni MD, Paolo Silvani MD, and Alberto Zangrillo MD

- **方法**：採訪在ICU外以NIV成功治療急性呼吸衰竭的患者。
- **結果**：45名患者納入研究。只有20%的人參與了NIV參數的初始設置。超過**40%**的人表示他們從未有過討論NIV治療。**百分之八十從未被要求嘗試其他界面**。所有受試者都知道如何尋求幫助，但只有四分之一的人接受過去除面罩的培訓，22%的受訪者表示如果需要的話根本無法去除面罩。一半的受試者報告說在需要時立即得到了幫助，但15%的受試者等待超過3分鐘。所有受試者均報告併發症，18%報告病情惡化。
- **結論**：受試者報告NIV治療的初始設置參與程度低，與護理人員溝通的滿意度低，以及緊急情況下的安全水平不理想

Respiratory Care May 2012, 57 (5) 704-709

- 大多數患者報告他們從未被要求嘗試另一種界面
- 界面選擇對於患者舒適度和NIV成功至關重要。
- 可能RT對NIV患者照護的時間不足，或缺乏深入了解界面選擇或在不同界面之間轉換的培訓。
- 如果患者對面罩不耐受，很可能導致NIV失敗
- 而用止痛鎮靜，以提高患者耐受NIV ，在普通病房的設置是不安全的
- 大多數受試者表示，他們沒有接受過去除面罩的培訓，或者根本無法將其移除。
- 應注意病人在嘔吐的情況或呼吸器失效時，是否有及時移除呼吸面罩的能力。

# 如何優化普通病房的NIV治療

- 使用實際NIV設備和全尺寸人體模型培訓參與者相關技能。
- 與患者的良好溝通，花足夠的時間來獲得他/她的合作
- 持續關注他/她的需求，以及選擇最舒適的界面
- 設置最佳通氣參數提高成功率。
- 持續或定期收集患者對NIV治療的看法以及對於NIV的常規數據收集

# Checklist at initiation of NIV

**First Huddle, at initiation of NIV**

| | Yes | No |
|---|---|---|
| Is NIV being used in lieu of intubation? | ☐ | ☐ |
| Does the patient have hypoxemic respiratory failure? (not related to cardiogenic edema or immunocompromise) | ☐ | ☐ |
| Will the patient be intubated if NIV fails? | ☐ | ☐ |
| Are relative contraindications for NIV present? (altered mental status, airway protection, aspiration risk, copious secretions) | ☐ | ☐ |
| Is patient tolerating NIV poorly/appearing uncomfortable? | ☐ | ☐ |
| Is much coaching required for patient to tolerate NIV? | ☐ | ☐ |
| Will frequent titration of settings be required? | ☐ | ☐ |
| Is patient hemodynamically unstable? | ☐ | ☐ |
| Does patient remain hypoxemic? ($SpO_2$ < 92% or $FIO_2$ > 0.6) | ☐ | ☐ |

***A "yes" response to any of the above should prompt consideration of transfer to ICU.***

What is the goal for NIV in this patient?

How will we decide if NIV is failing?

What is the alternative if NIV fails?

Has pulmonary medicine been consulted? _____ yes _____ no

(Massachusetts General Hospital)

# Checklist after 2 hours of NIV

**Second Huddle, after 2 hours of NIV**

| | Yes | No |
|---|---|---|
| Has gas exchange and dyspnea improved in past 2 hours? | ☐ | ☐ |
| Is the goal of NIV being met? | ☐ | ☐ |
| Does patient tolerate removal of the mask for at least 30 minutes? | ☐ | ☐ |
| Is patient tolerating NIV and comfortable? | ☐ | ☐ |
| Is $SpO_2 > 92\%$ and $FIO_2 < 0.6$? | ☐ | ☐ |
| Is patient hemodynamically stable? | ☐ | ☐ |
| Does patient tolerate NIV without excessive coaching? | ☐ | ☐ |
| Is patient stable on IPAP ≤ 15 cm $H_2O$? | ☐ | ☐ |

***A "no" response to any of the above should prompt consideration of transfer to the ICU.***

Will patient be moved to ICU? _____ yes _____ no

If no, has pulmonary medicine been consulted? _____ yes _____ no

Has the medical attending been notified? _____ yes _____ no

(Massachusetts General Hospital)

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# Patient-ventilator asynchrony

- NIV失敗率（需要插管）可能高達40%。其中一些失敗可能與**asynchrony**有關。
- 在一項研究中，43%的受試者在NIV期間發生了高比率的**asynchrony** 。
- NIV期間**Patient-ventilator asynchrony**與潛在的疾病過程和**air leak**的存在有關
- 減少與接面的**air leak**並使用具有良好**air leak**補償的呼吸器可降低**Patient-ventilator asynchrony**

Respir Care2011;56(2):153-165;

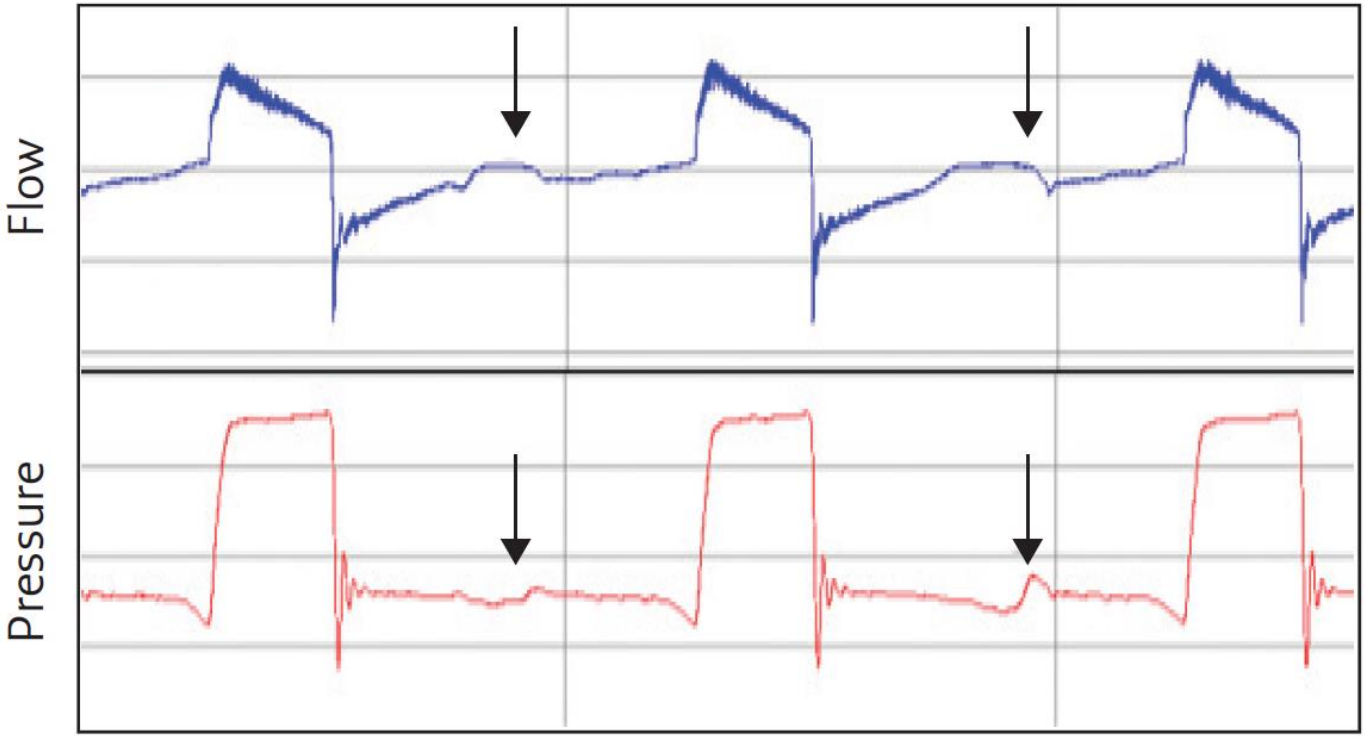


*Figure 3. A typical patient–ventilator asynchrony pattern due to ineffective efforts during NIV that may be easily identified by looking at the flow–pressure curves of the ventilator. Arrows indicate the wasted efforts performed by the patient to successfully trigger the ventilator. Reproduced from Vignaux* et al. *(2009)* Intensive Care Med; *35: 840–846, with permission from the publisher.*

**ERS Practical Handbook of Noninvasive Ventilation**
**Edited by Anita K. Simonds 2015**

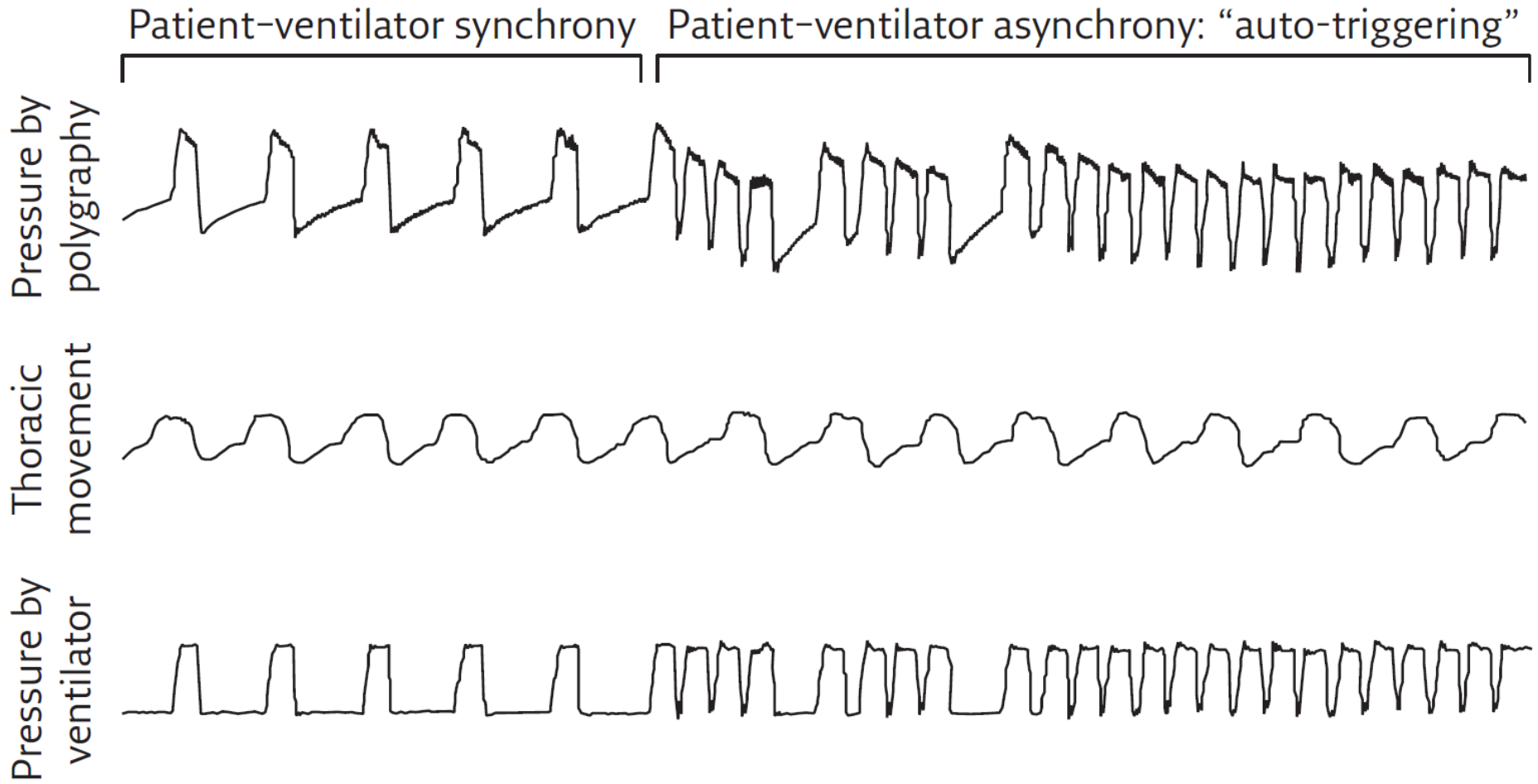


*Figure 3. Patient-ventilator asynchrony during mechanical ventilation after five regular breaths. Periodic breathing patterns by the subject (thoracic movements) are not detected by the ventilator and breathing frequency (pressure curves) is increased without patient effort (so-called "auto-triggering"). Reproduced and modified from Storre* et al. *(2014a), with permission from the publisher.*

# Sedation for interface intolerance

- 15%, 6%, and 28% never used **sedation, analgesia, or hand restraints** for patients receiving NIV.
- Sedation, analgesia, and hand restraints were more commonly used in **North America** than in Europe.
- A **benzodiazepine** alone was the most preferred (33%), followed by an opioid alone (29%)

Crit Care Med2007;**35**(10):2298-2302

# When to sedate

- **NIV failure due to patient refusal to continue NIV because of discomfort, claustrophobia or marked agitation.**

**exclusion criteria were:**

- poor respiratory state requiring immediate intubation
- severely altered consciousness
- any patient requiring an immediate lifesaving intervention such as cardiopulmonary resuscitation, airway control, cardioversion or inotropic support

**(Intern Med 51: 2299-2305, 2012)**

Remifentanil(starting at 0.025 μg/kg/min and titrating up to 0.12 μg/kg/min as needed).

- a **potent short-acting synthetic opioid** used for pain relief and sedation
- sedated to a Ramsay scale of 2–3 by a continuous infusion of remifentanil during NIV.
- tolerance improved
- $P_{aO2}/F_{IO2}$ increased
- breathing frequency decreased
- $P_{aCO2}$ decreased

**Intensive Care Med 2007;33(1):82-87**
**Intensive Care Med 2010;36(12):2060-2065**

esth Analg 2008;107(1):167-170

# Dexmedetomidine（1 mcg/kg的初劑量, 0.2 至0.7 mcg/kg/hr的維持劑量）

- an ideal pharmacologic agent for sedation of patients intolerant of NIV
- a prospective clinical investigation in 10 subjects in whom NIV was difficult because of agitation.
- All subjects were successfully weaned from NIV, and the respiratory state was not worsened

Anesth Analg 2008;**107**(1):167-170
**J Anesth 2009;23(1):147-150**
**Respir Care 2012;57(11):1967-1969**

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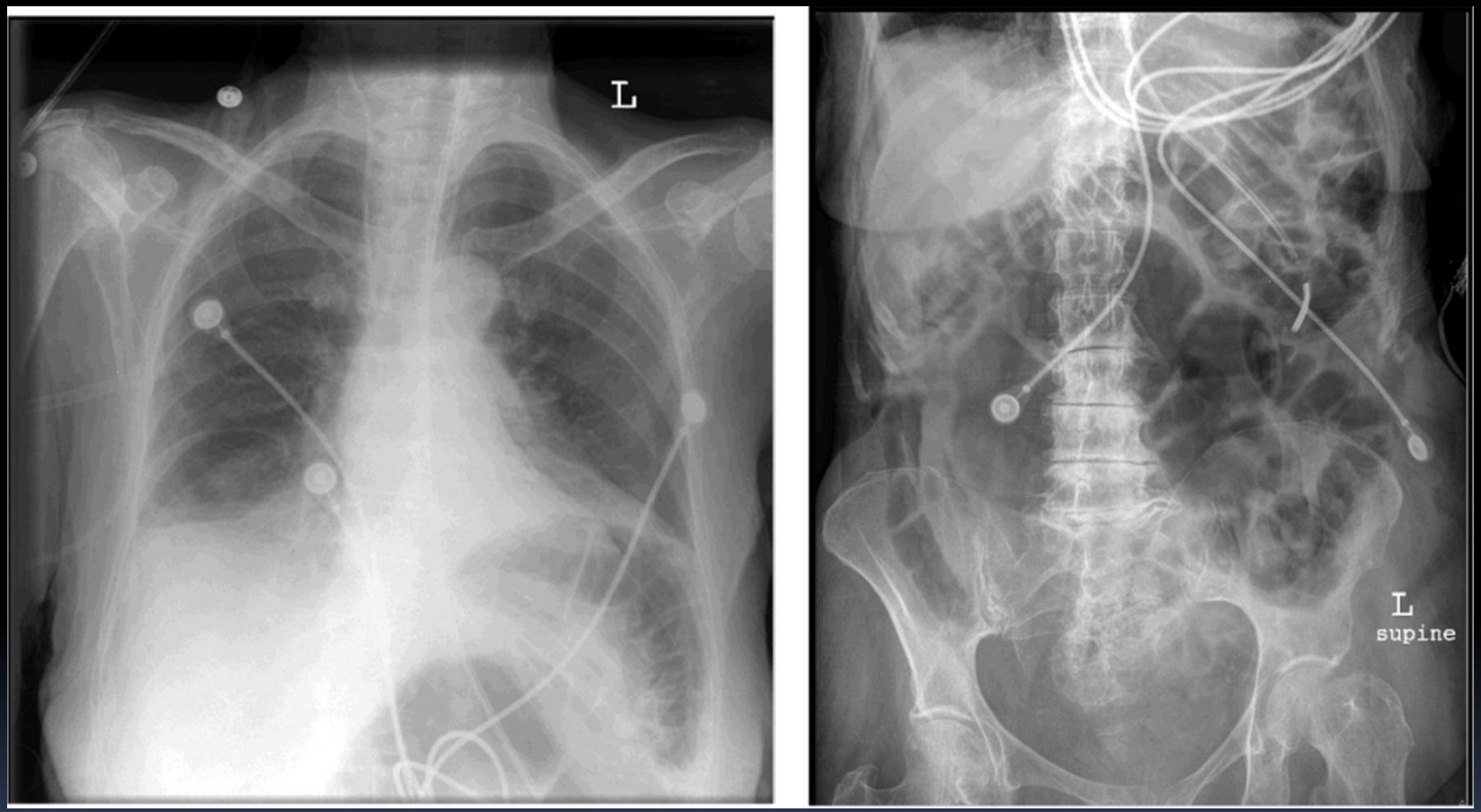
# Chest and abdomen radiographs of a patient who developed severe gastric insufflation while receiving noninvasive ventilation.



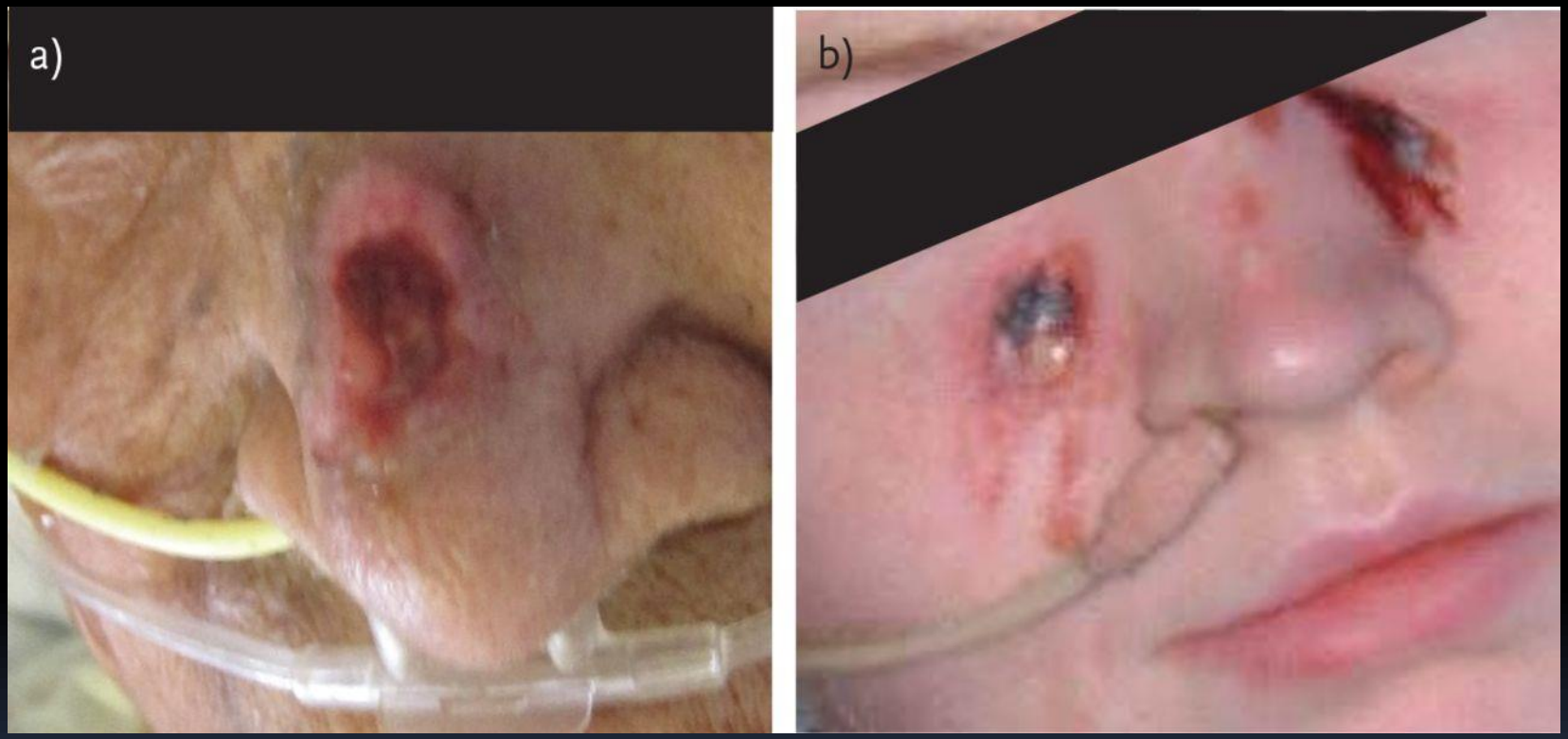

Dean R Hess Respir Care 2013;58:950-972

- NIV通常會出現食道注氣(aerophagia)，但這通常是良性的，因為氣道壓力低於食管開口壓力。
- 胃注氣可能很嚴重，但這通常是吸氣壓力設置過高的結果。
- 對於面罩通氣，通常不需要胃管。

# facial skin breakdown

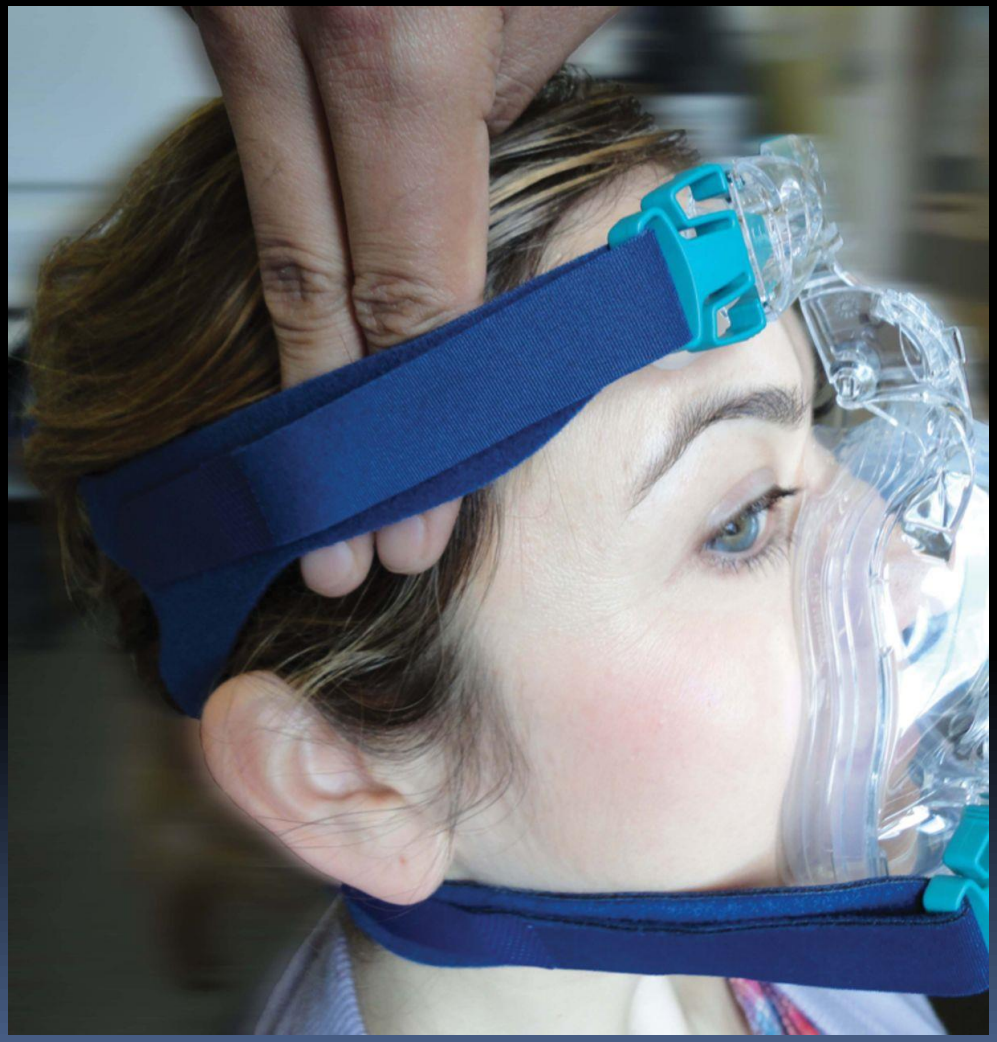
- A potential problem with **nasal and oronasal masks**
- most commonly occurs on the **bridge** of the nose.
- Nasal skin breakdown has been estimated to occur in **5–20%** of applications of NIV
- the most important approach to prevent skin breakdown is to **avoid strapping the mask too tight**

a) Grade III pressure ulcer on the nasal bridge
b) grade II pressure ulcers on the cheeks



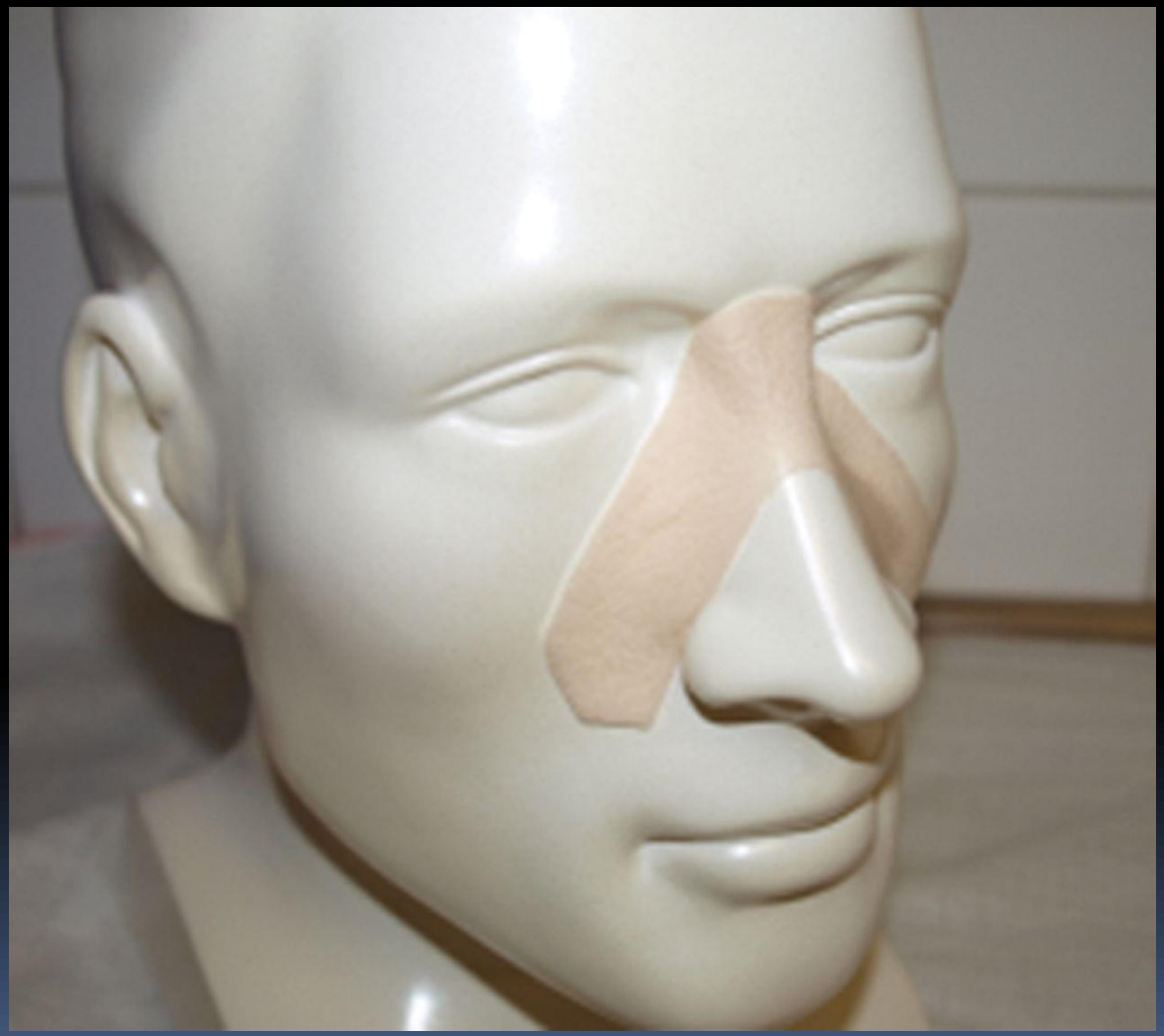

Anne-Kathrin Brill Breathe 2014;10:230-242

**The two-finger rule: when the headgear is attached it should be possible to pass two fingers beneath it [30].**



**Anne-Kathrin Brill Breathe 2014;10:230-242**

# Example for skin protection: a self-cut foam (Mölnlycke Health Care, Göteborg, Sweden) dressing on a head model.





Anne-Kathrin Brill Breathe 2014;10:230-242

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# Official ERS/ATS clinical practice guidelines: noninvasive ventilation for acute respiratory failure

Bram Rochwerg[1], Laurent Brochard[2,3], Mark W. Elliott[4], Dean Hess[5], Nicholas S. Hill[6], Stefano Nava[7] and Paolo Navalesi[8] (members of the steering committee); Massimo Antonelli[9], Jan Brozek[1], Giorgio Conti[9], Miquel Ferrer[10], Kalpalatha Guntupalli[11], Samir Jaber[12], Sean Keenan[13,14], Jordi Mancebo[15], Sangeeta Mehta[16] and Suhail Raoof[17,18] (members of the task force)

Eur Respir J 2017; 50:

TABLE 1 Interpretation of strong and conditional recommendations for stakeholders (patients, clinicians and healthcare policy makers)

| | Strong recommendation | Weak recommendation |
|---|---|---|
| **For patients** | Most individuals in this situation would want the recommended course of action and only a small proportion would not. | The majority of individuals in this situation would want the suggested course of action, but many would not. |
| **For clinicians** | Most individuals should receive the recommended course of action. Adherence to this recommendation according to the guideline could be used as a quality criterion or performance indicator. Formal decision aids are not likely to be needed to help individuals make decisions consistent with their values and preferences. | Different choices are likely to be appropriate for different patients and therapy should be tailored to the individual patient's circumstances. Those circumstances may include the patient or family's values and preferences. |
| **For policy makers** | The recommendation can be adapted as policy in most situations including for the use as performance indicators. | Policy making will require substantial debates and involvement of many stakeholders. Policies are also more likely to vary between regions. Performance indicators would have to focus on the fact that adequate deliberation about the management options has taken place. |

- **Strong recommendation**

-Hypercapnia with COPD exacerbation

-Cardiogenic pulmonary edema

- **Conditional recommendation**

-Immunocompromised

-Post-operative

-Palliative care

-Trauma

-Weaning in hypercapnic patients

-Post-extubation in high risk patient

- **No recommendation**

-*De novo* respiratory failure

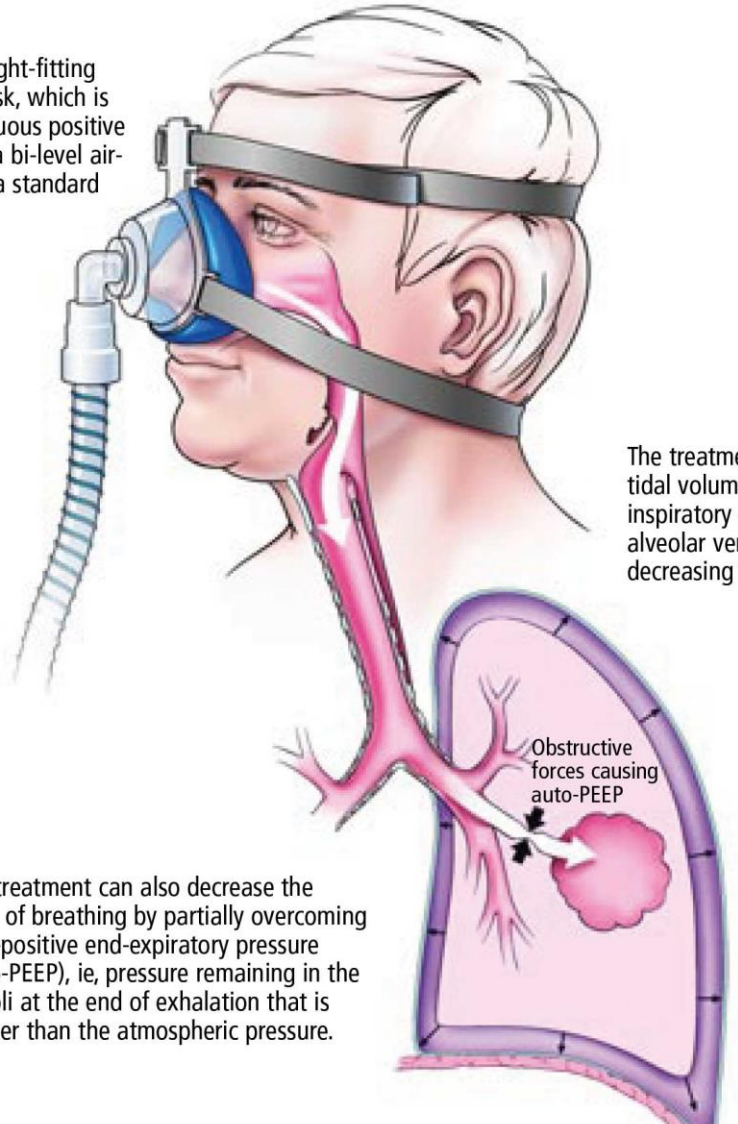
- Acute asthma exacerbation

# HYPERCAPNIA WITH COPD EXACERBATION

# Noninvasive positive pressure ventilation: An effective therapy in acute exacerbations of COPD

In selected patients with hypercapnic respiratory failure due to an acute exacerbation of chronic obstructive pulmonary disease (COPD), noninvasive positive pressure ventilation, added to usual medical therapy, reduces the need for endotracheal intubation, the length of hospital stay, and the risk of death.

The patient wears a tight-fitting nasal or full facial mask, which is connected to a continuous positive airway pressure unit, a bi-level airway pressure unit, or a standard ventilator.




The treatment provides a larger tidal volume with the same inspiratory effort, thus improving alveolar ventilation and decreasing the work of breathing.

This treatment can also decrease the work of breathing by partially overcoming auto-positive end-expiratory pressure (auto-PEEP), ie, pressure remaining in the alveoli at the end of exhalation that is greater than the atmospheric pressure.

# Bilevel NIV to prevent intubation in respiratory acidosis

- improvement in **pH or respiratory rate**, is a good predictor of a successful outcome
- response is almost universally seen within the first **1–4 h after NIV**
- ↓ dyspnoea
- ↓ intubation rate
- ↓ ICU admission
- ↓ hospital length of stay
- ↓ respiratory and nonrespiratory infection
- ↑ survival

ERS/ATS guideline 2017

# COPD with hypercapnia

| PH>7.35 | PH:7.25-7.35 | PH<7.25 |
| --- | --- | --- |
| • Condition against | • Strong recommend | • Strong recommend |

# COPD post-extubation

| Weaning | Prevention | Failure treat |
| --- | --- | --- |
| • Condition recommend | • Condition recommend | • Condition against |

ERS/ATS guideline 2017

# Recommendation

- We suggest NIV not be used in patients with hypercapnia who are not acidotic in the setting of a COPD exacerbation.
- (Conditional recommendation, low certainty of evidence)

# Recommendations

- **We recommend bilevel NIV for patients with ARF leading to acute or acute-on-chronic respiratory acidosis (pH ⩽7.35) due to COPD exacerbation.**
- **(Strong recommendation, high certainty of evidence.)**

ERS/ATS guideline 2017

# Recommendations

- We recommend a trial of bilevel NIV in patients considered to require endotracheal intubation and mechanical ventilation, unless the patient is immediately deteriorating.
- (Strong recommendation, moderate certainty of evidence.)

ERS/ATS guideline 2017

- There is no lower limit of pH below which a trial of NIV is inappropriate
- However, the lower the pH, the greater risk of failure, and patients must be very closely monitored with rapid access to endotracheal intubation and invasive ventilation if not improving.

ERS/ATS guideline 2017

# NIV in Asthma Exacerbations

- IPAP:14 :cmH2O + EPAP: 6 cmH2O➔ a 20% improvement in FEV1 (*P< .05).*

  ----Intern Med 2008;47(6):493-501.

- A Cochrane review considered NIV for asthma promising but controversial.

  ------Cochrane Database Syst Rev 2012;12

- some patients can deteriorate rapidly and develop very-severe obstruction
- European Respiratory Society/American Thoracic Society guideline

  ➔no recommendation due to a lack of evidence.

# Decompensated Obesity-Hypoventilation Syndrome

- BiPAP initiated in a monitored setting
- BiPAP successfully averts endotracheal intubation in over 90 percent of patients
- Volume-cycled positive pressure ventilation (VCPPV) for insufficient alveolar ventilation with BiPAP.

Am J Respir Crit Care Med 2012;186(12):1279-1285.

# HFNC in Acute Hypercapnic Respiratory Failure

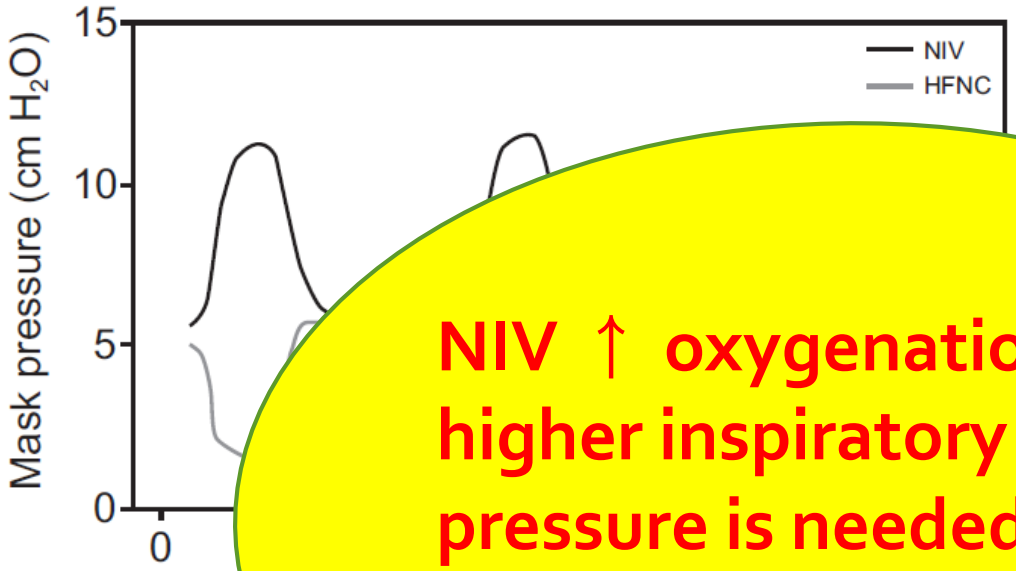



Fig. 1. Mask pressu
by using a bi-level venti
and expiratory pressure o
tracing during high-flow nasa
60 L/min. Expiratory pressures are
(declining during expiration as patie
but during inspiration, pressure rises
NIV and drops to 2 cm $H_2O$ during HFNC. Data are from ventilator tracings and Reference 60. Illustration was by W. Hill.

**NIV ↑ oxygenation when higher inspiratory pressure is needed such as COPD exacerbations or pulmonary edema.**

Respir Care 2019;64(6):647–657.

# NIV IN CARDIOGENIC PULMONARY EDEMA

# Physiological effect of NIV

**Table 2 Main physiologic effects of positive intrathoracic pressure**

Cardiovascular

↓ Venous return → ↓ RV preload → ↓ LV preload

↑ Pulmonary vascular resistance → ↑ RV afterload → RV enlargement →↓ LV Compliance

↓ LV afterload (↓ systolic wall stress)

↓ Systemic blood pressure → ↓ Cardiac output[a]

Respiratory

Recruitment of collapsed alveoli → ↑Functional residual capacity

Maintenance continuously opened alveoli→ Gas exchange during the whole respiratory cycle

Intra-alveolar pressure against oedema

↓ Work of breathing

↑ Oxygenation

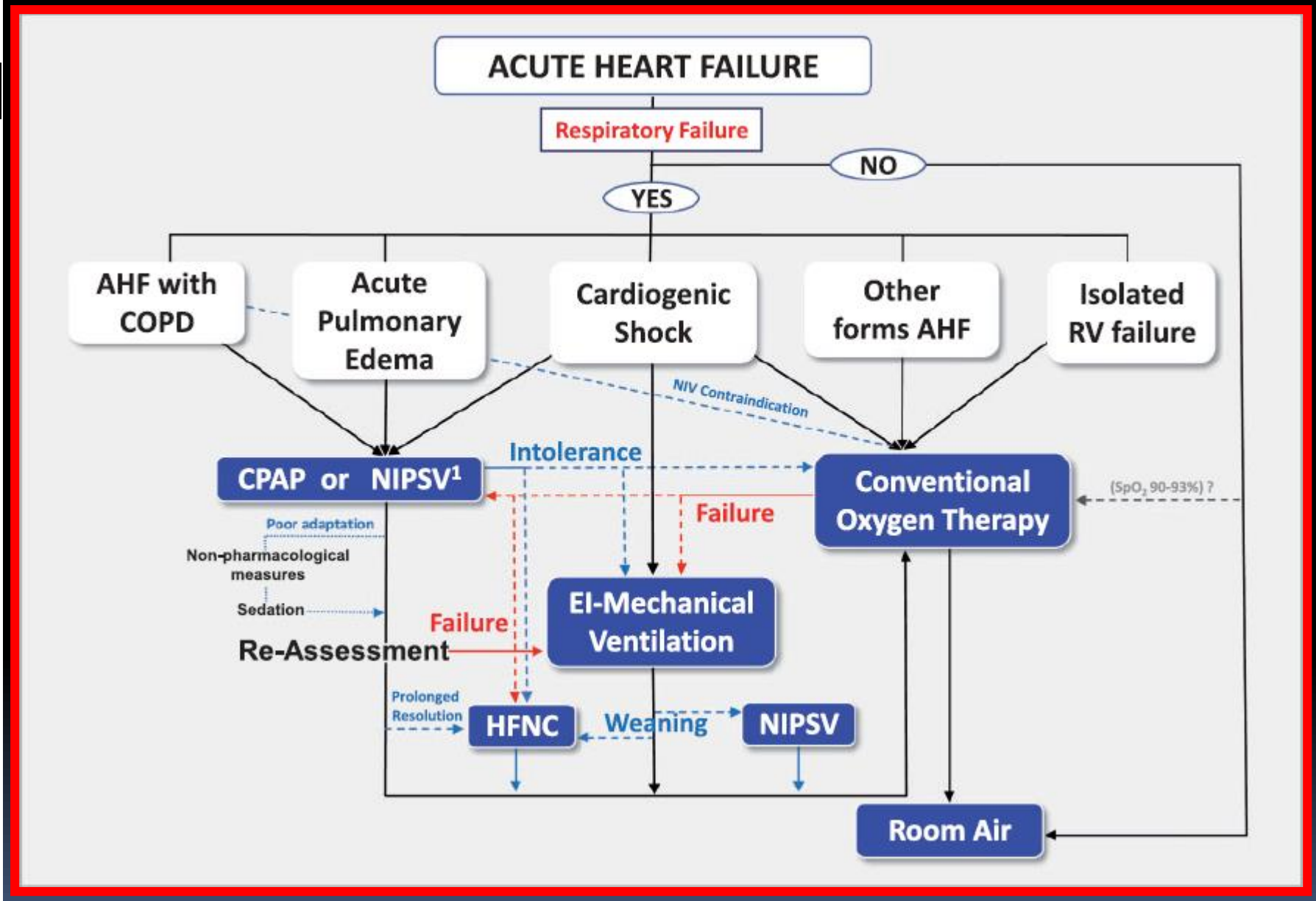
# ERS/ATS guidelines

- We recommend either bilevel NIV or CPAP for patients with ARF due to cardiogenic pulmonary edema
- acute coronary syndrome or cardiogenic shock excluded
- (Strong recommendation, moderate certainty of evidence.)

# Guidelines

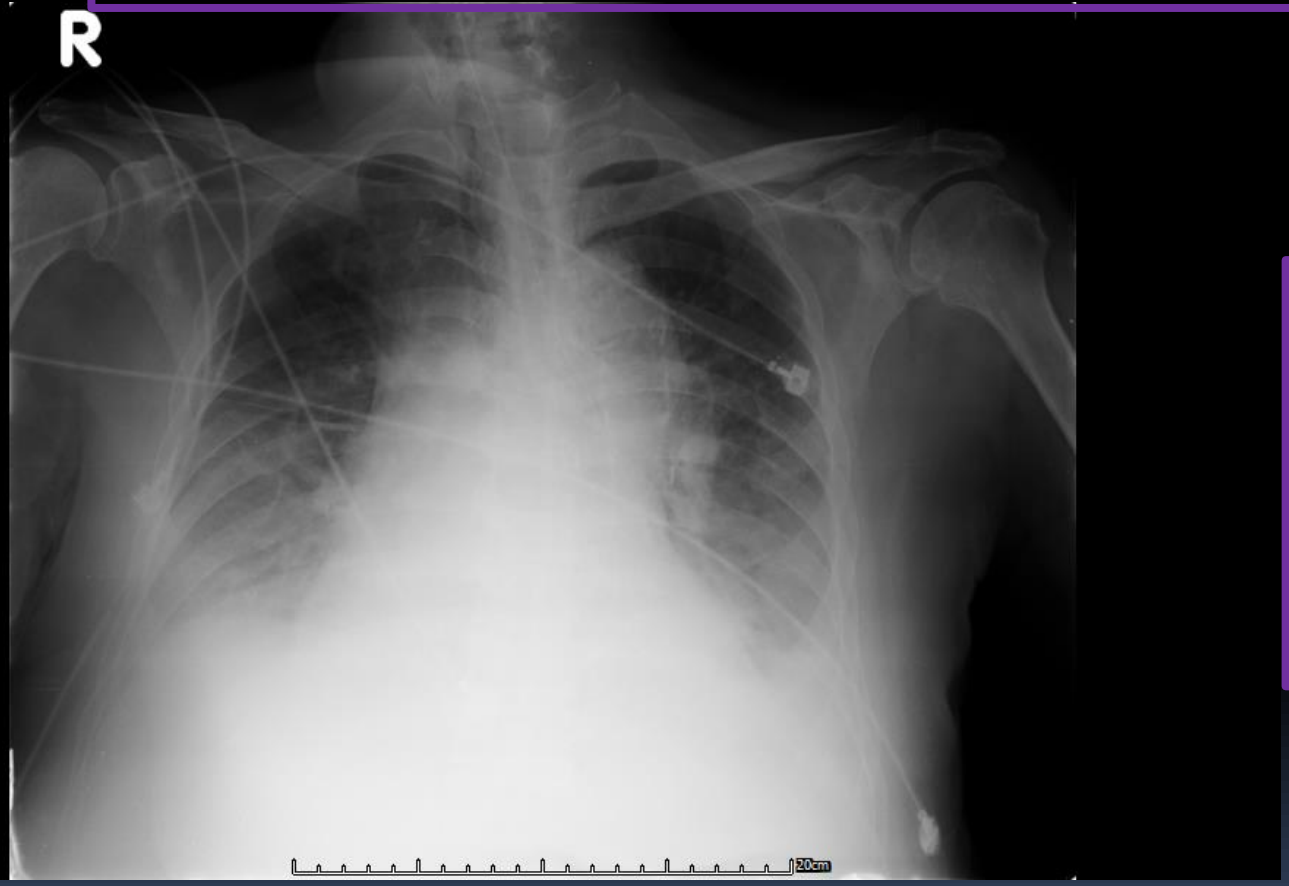
| Society | Recommendation | Evidence |
|---|---|---|
| ERS/ATS 2017 | We recommend either bilevel NIV or CPAP for patients with ARF due to cardiogenic pulmonary oedema. | Strong recommend, moderate evidence |
| ESC 2016 | Non-invasive positive pressure ventilation (CPAP, BiPAP) should be considered in patients with respiratory distress (**respiratory rate >25** breaths/min**, SpO2 <90%)** and started as soon as possible in order to decrease respiratory distress<br>…<br>**Blood pressure** should be monitored regularly when this treatment is used. | Class: IIa<br>LOE: B |
| AHA 2013 | (No NIV description) | |
| TSOC 2012 | ….It is recommended that non-invasive ventilation should be initiated as early as possible in acute heart failure patients with dyspnea and respiratory distress if no obvious contraindication…. | No grading |

Eur Heart J. 2016;37:2129–2200
Acta Cardiol Sin 2012;28:161-195



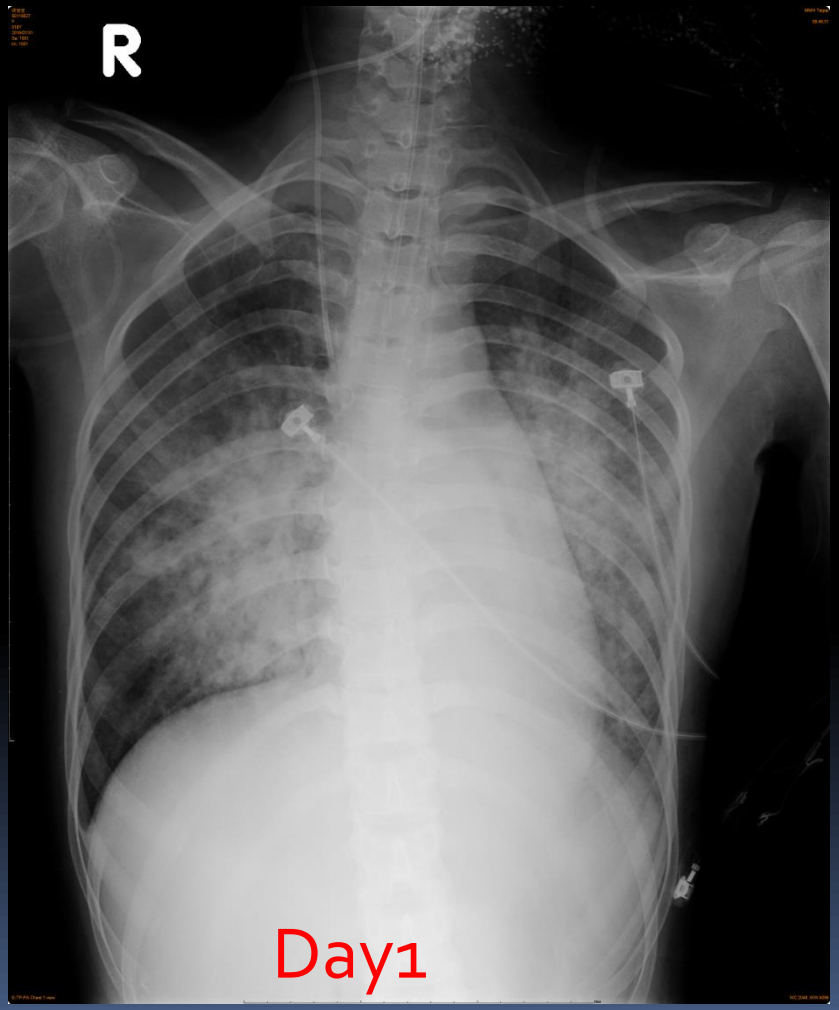

Eur Heart J. 2018 Jan 1;39(1):17-25

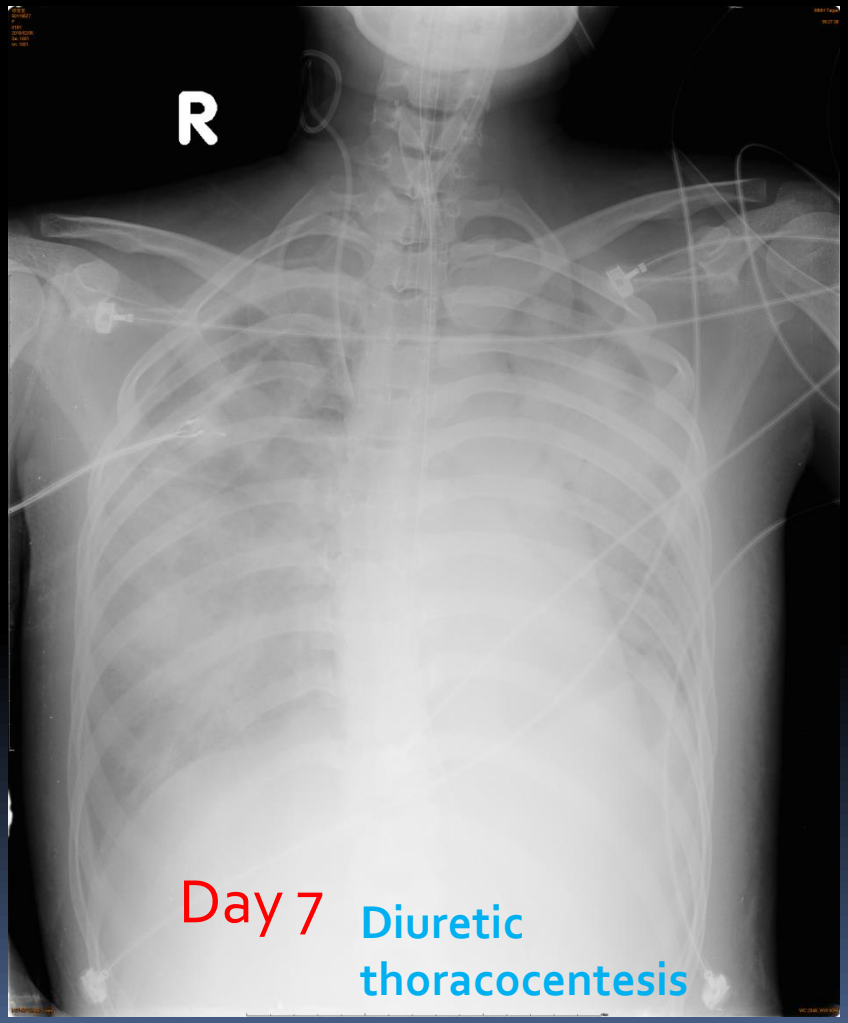
89 y/o male , ADHF with pulmonary edema
HCVD, NIDDM , **BNP 3500 pg/mL**




| Aerosal Mask 濃度：1.0 | | |
|---|---|---|
| pH | 7.262 | |
| $pCO_2$ | 80 | mmHg |
| $pO_2$ | 87 | mmHg |
| $HCO_3$ | 36 | mmol/L |
| B.E. | 6.7 | mmol/L |
| $SaO_2$ | 94.3 | % |

# 18 y/o female Infective endocarditis with severe MR & mild AR



# NIV in ARF in the post-operative setting

# NIV in the treatment of ARF in postoperative patients

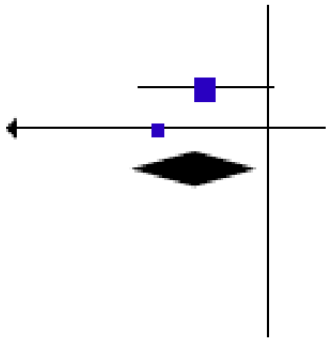
Mortality

**1.1.2 Treatment of ARF in postop patients**

| | | | | | | |
|---|---|---|---|---|---|---|
| Auriant 2001 | 3 | 24 | 9 | 24 | 38.3% | 0.33 [0.10, 1.08] |
| Squadrone 2005 | 0 | 105 | 3 | 104 | 14.9% | 0.14 [0.01, 2.71] |
| **Subtotal (95% CI)** | | **129** | | **128** | **53.2%** | **0.28 [0.09, 0.84]** |
| Total events | 3 | | 12 | | | |

Heterogeneity: $Chi^2 = 0.29$, $df = 1$ ($P = 0.59$); $I^2 = 0\%$

Test for overall effect: $Z = 2.28$ ($P = 0.02$)



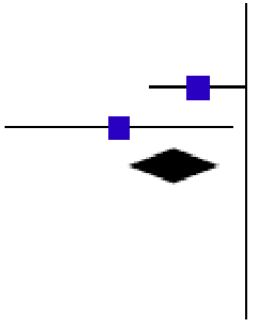
Intubation

**1.2.2 Treatment of ARF in postop patients**

| | | | | | | |
|---|---|---|---|---|---|---|
| Auriant 2001 | 5 | 24 | 12 | 24 | 42.9% | 0.42 [0.17, 1.00] |
| Squadrone 2005 | 1 | 105 | 10 | 104 | 35.9% | 0.10 [0.01, 0.76] |
| **Subtotal (95% CI)** | | **129** | | **128** | **78.9%** | **0.27 [0.12, 0.61]** |
| Total events | 6 | | 22 | | | |

Heterogeneity: $Chi^2 = 1.85$, $df = 1$ ($P = 0.17$); $I^2 = 46\%$

Test for overall effect: $Z = 3.13$ ($P = 0.002$)



Chiumello D, Intensive Care Med 2013; 37: 918–929.

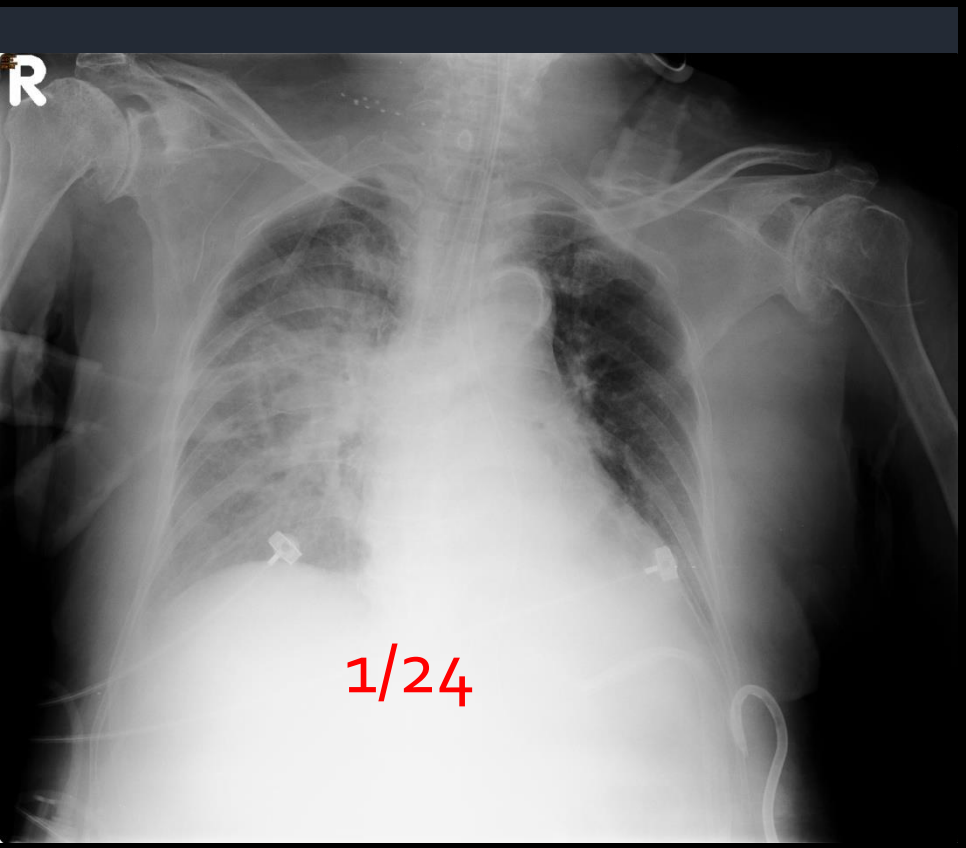
# Recommendation

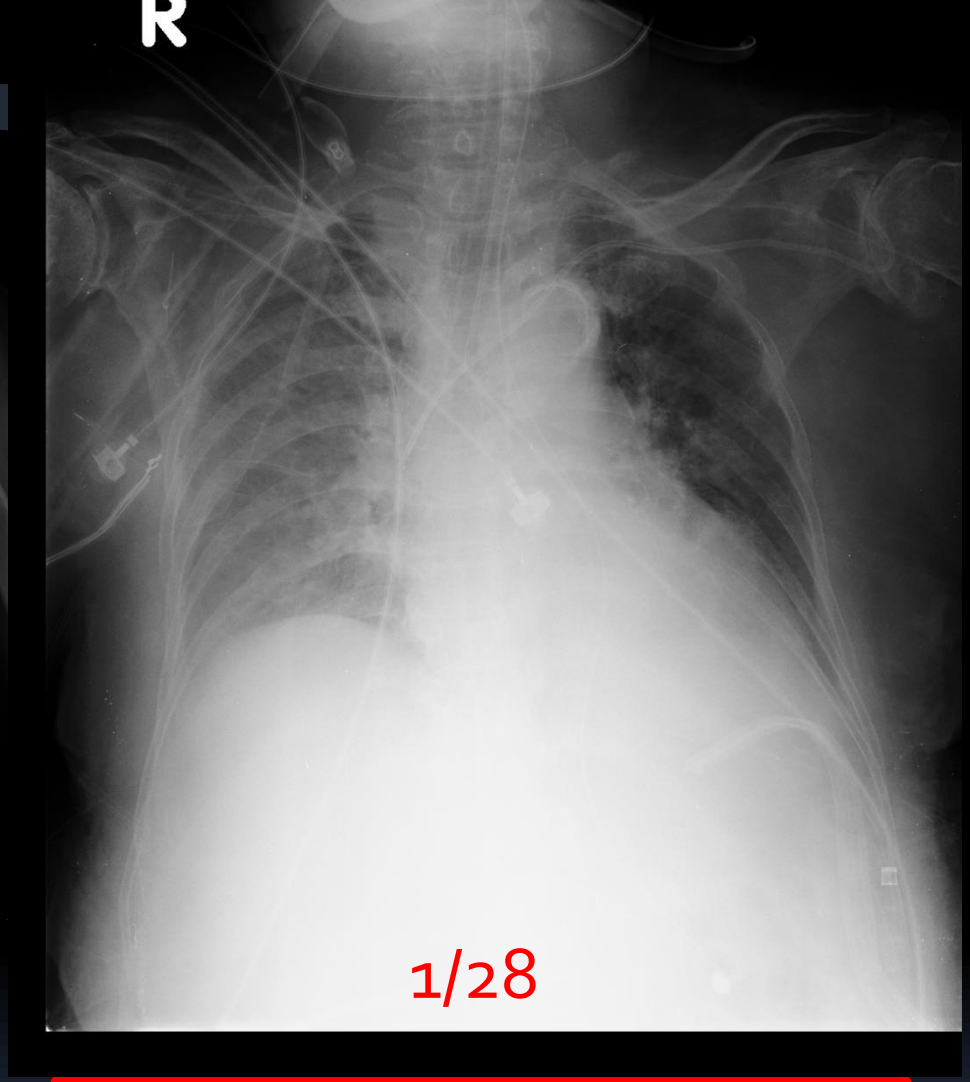
**We suggest NIV for patients with post-operative ARF.**

**(Conditional recommendation, moderate certainty of evidence.)**

# 87 y/o female

- PPU, accepted Subtotal Gastrectomy (2016/12/21) at xx醫院
- Dirty ascites was noted with culture yielded VRE (2017/01/06)
- Difficult weaning , patient was to undergo tracheostomy at 01/22
- CPCR durning tracheostomy for 3 minutes
- 1/24 transfer to MMH




NT-ProBNP 3356 pg/mL

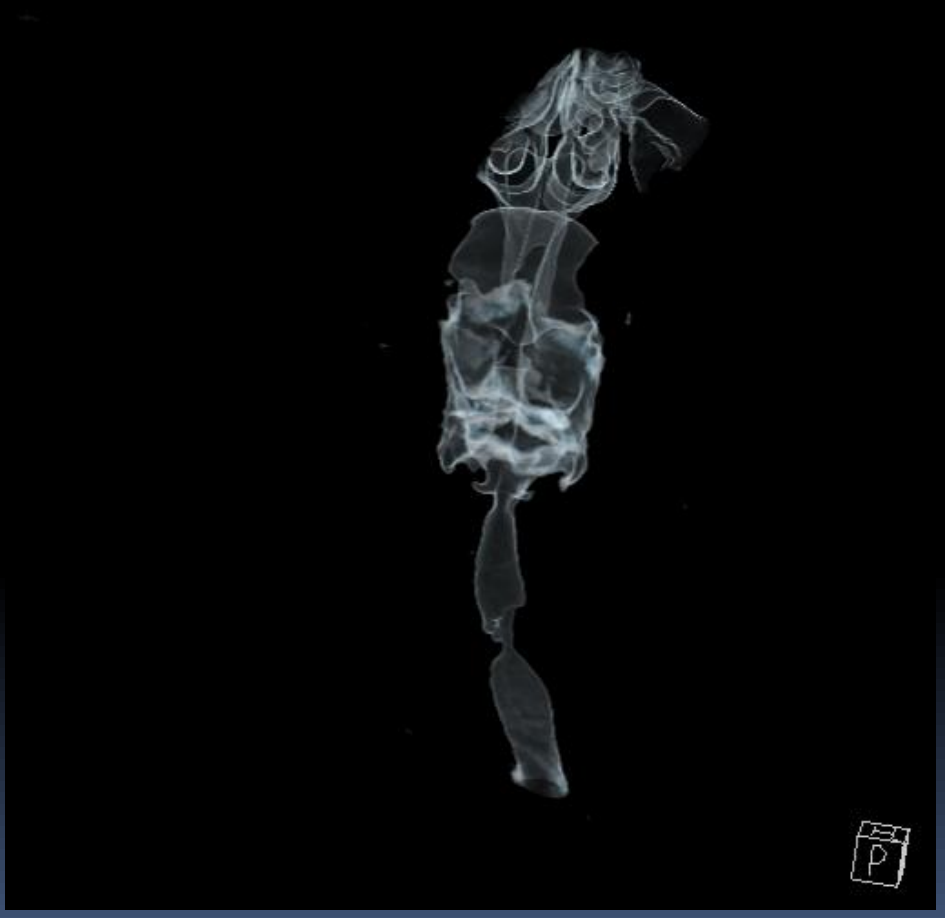
- 最大吸氣壓 -20 cmH2O
- 最大吐氣壓 22 cmH2O
- VE 6.57 L/min
- RSI 80.7
- VT 286 ml

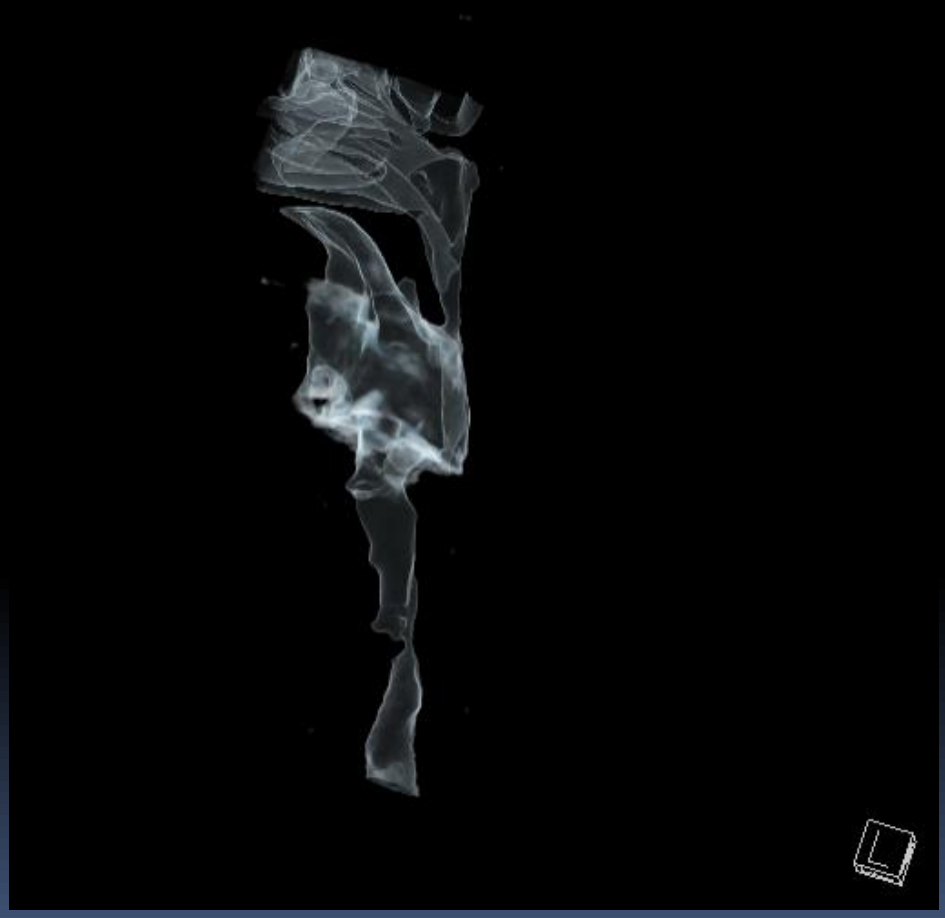
| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 2017/02/01 08:30 | ST | /362 | 16/22 | 0.8/1:2.2 | / | /9.5 | / | /8 | /18 |
| 2017/01/31 20:00 | ST | /328 | 16/26 | 0.9/1:1.3 | / | /8.0 | / | /8 | /18 |
| 2017/01/31 11:05 | ST | /571 | /15 | 1.0/1:1.5 | / | /7.9 | / | /8 | /18 |
| 2017/01/31 08:40 | Mask | / | / | / | 10L/ | / | / | / | / |
| 2017/01/31 07:50 | HFNC | / | /31 | / | 50L/ | / | / | / | / |
| 2017/01/30 14:15 | →HFNC | / | /26 | / | 50L/ | / | / | / | / |
| 2017/01/30 09:10 | →Mask | / | /24 | / | 10L/ | / | / | / | / |
| 2017/01/30 09:05 | HFNC | / | /29 | / | 50L/ | / | / | /5 | / |
| 2017/01/29 10:10 | HFNC | / | /28 | / | 50L/ | / | / | /5 | / |
| 2017/01/28 16:00 | HFNC | / | /21 | /1: | 50L/ | / | / | /5 | / |
| 2017/01/28 08:55 | CPAP | /276 | /25 | / | / | /7.6 | 11/ | 9/8.0 | / |
| 2017/01/27 09:45 | PSV | /408 | /19 | / | / | /7.7 | 18/ | 8/5.0 | →12.0/ |
| 2017/01/27 09:15 | PSV | /385 | /15 | / | / | /7.0 | 20/ | 7/5.0 | 14.0/ |
| 2017/01/26 09:15 | →PSV | /322 | /23 | / | / | /8.4 | 20/ | 9/5.0 | 14.0/ |
| 2017/01/26 08:45 | VCV | 400/408 | 12.0/13 | 1.00/1.0:4... | AutoFlow/ | /5.8 | 23/ | 9/5.0 | / |
| 2017/01/26 00:05 | VCV | 420/659 | →16.0/18 | 1.00/1.0:2... | AutoFlow/ | /8.5 | 35/ | 13/5.0 | / |
| 2017/01/25 16:25 | VCV | 420/478 | 18.0/19 | 1.00/1.0:2... | AutoFlow/ | /9.0 | 26/ | 11/5.0 | / |
| 2017/01/25 15:03 | VCV | 420/368 | 18.0/28 | 1.00/1.0:2... | AutoFlow/ | /13.5 | 38/ | 18/5.0 | / |
| 2017/01/25 09:30 | VCV | 420/518 | 12.0/20 | 1.00/1.0:4... | AutoFlow/ | /9.4 | 26/ | 11/5.0 | / |

檢驗日期：2017/01/28 17:20
氧氣治療種類：High Flow Nasal CPAP
濃度：45/PEEP5

| 項目名稱 | 結果值 | 單位 | 參考範圍 |
|---|---|---|---|
| pH | 7.510 | | (7.35 ~ 7.45) |
| $PaCO_2$ | 40.5 | mmHg | (32 ~ 45) |
| $PaO_2$ | 94.1 | mmHg | (75 ~ 100) |
| $HCO_3$ | 31.6 | mmol/L | (20 ~ 26) |
| BE | 7.9 | mmol/L | (-2 ~ +2) |
| PF ratio | 209.11 | | |

# 3D reconstruction CT



# PALLIATIVE CARE

# Noninvasive Ventilation in Patients With Do-Not-Intubate and Comfort-Measures-Only Orders: A Systematic Review and Meta-Analysis*

- 2,020 patients with acute respiratory failure & DNI orders
- **Hospital discharge** survival rate: **56%** (95% CI, 49-64%)
  **1 year** Survival rate: **32%** (95% CI, 21-45%)
- **Hospital survival :**
  **COPD :68%**
  **Pulmonary edema: 68%,**
  **Pneumonia:41%**
  **Malignancy.:37%**
- Survival was comparable in hospital ward versus an ICU.
- Quality of life of survivors was not reduced compared with baseline

Wilson ME et al. Crit Care Med. 2018 Aug;46(8):1209-1216

# Recommendation

- We suggest offering NIV to dyspneic patients for palliation in the setting of terminal cancer or other terminal conditions.
- (Conditional recommendation, moderate certainty of evidence.)

- Should NIV be used to facilitate weaning patients from invasive mechanical ventilation?

# COPD with hypercapnia

| PH>7.35 | PH:7.25-7.35 | PH<7.25 |
| --- | --- | --- |
| • Condition against | • Strong recommend | • Strong recommend |

# COPD post-extubation

| Weaning | Prevention | Failure treat |
| --- | --- | --- |
| • Condition recommend | • Condition recommend | • Condition against |

ERS/ATS guideline 2017

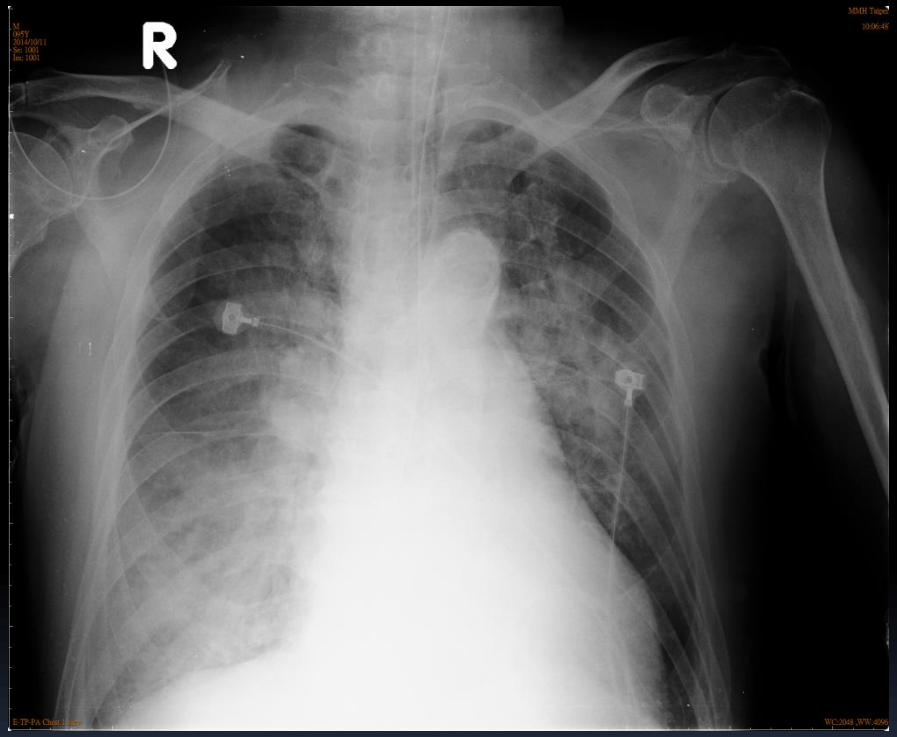
# Recommendations

- **We suggest NIV be used to facilitate weaning from mechanical ventilation in patients with hypercapnic respiratory failure.**

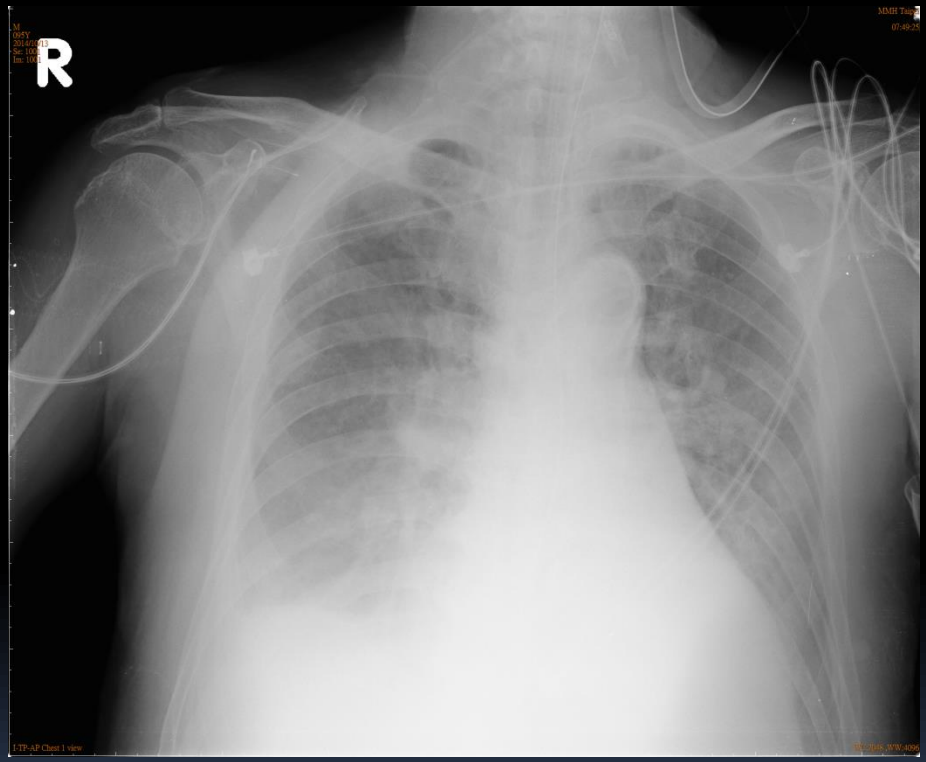
  (Conditional recommendation, moderate certainty of evidence.)

- We do not make any recommendation for hypoxaemic patients.

# 95 y/o male , COPD , CHF with pul. Edema , smoking 1 PPD for 60

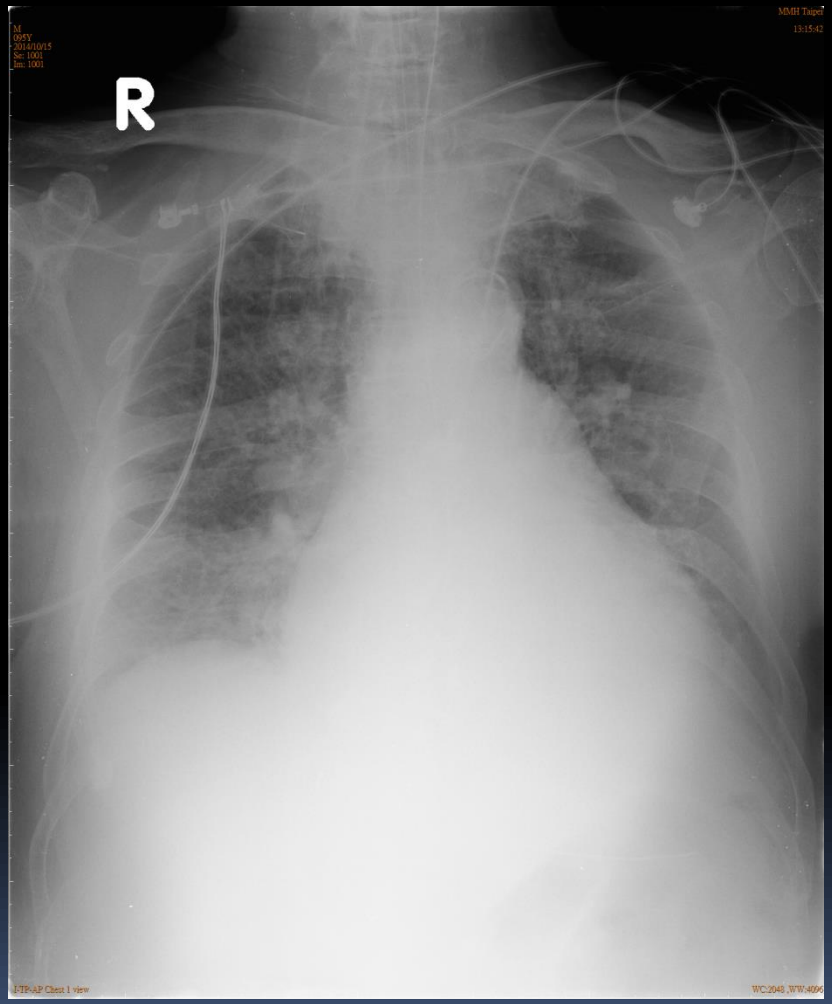


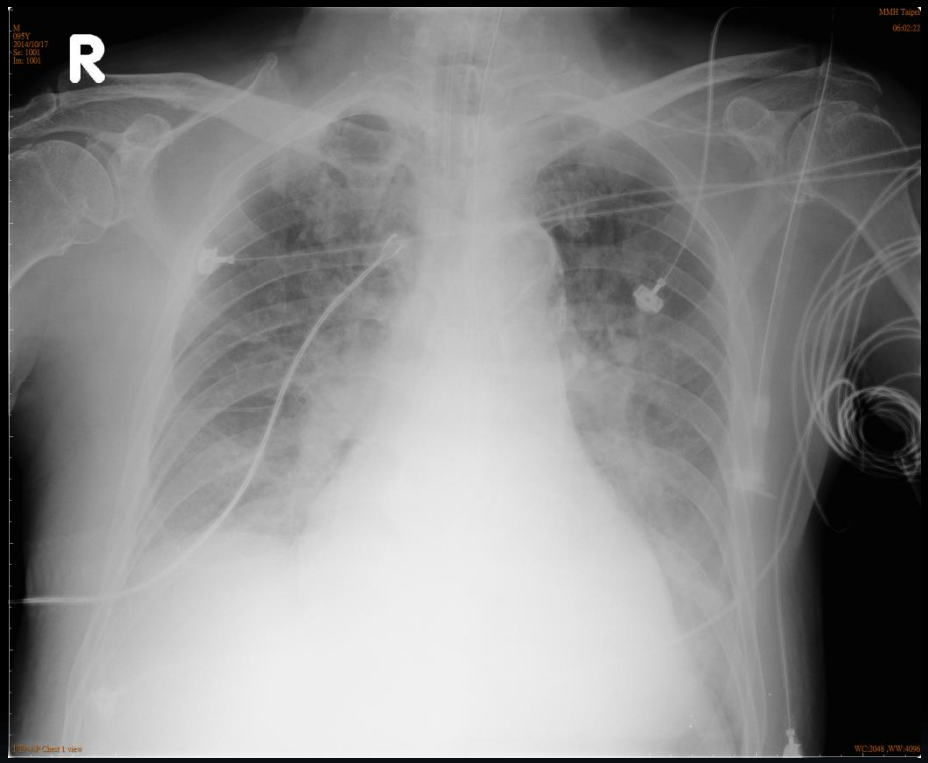

D1




D4

# D6 pre-Tpiece




最大吸氣壓 -14 cmH2O
最大吐氣壓 +20 cmH2O
全階呼吸量測定
VE 7.4 L/min
RSI 121
VT 246 ml

- Consult CV for CAG , Cardiologist hesitated
- Extubation at $FiO_2$:0.4
- Pressure support 12 $cmH_2O$
- PEEP 8 $cmH_2O$

- Should NIV be used in ARF following extubation from invasive mechanical ventilation?

Table 9. Criteria Used to Separate Subjects Into High Risk and Low Risk for Re-Intubation

| Mechanical Ventilation for at Least 12 h and at Least One of the Following | Low Risk | High Risk |
|---|---|---|
| Age 65 y | ≤ | > |
| APACHE II score of 12 at extubation | ≤ | > |
| BMI 30 kg/$m_2$ | ≤ | > |
| Pulmonary Secretions | No problem | Problem |
| Comorbidities | ≤1 | >1 |
| HF cause for mechanical ventilation | No | Yes |
| Moderate-severe COPD | No | Yes |
| Airway patency | No problem | Problem |
| Duration of mechanical venitlation | ≤7 d | >7 d |

Based on References 87 and 88.
APACHE = Acute Physiology and Chronic Health Evaluation
BMI = body mass index
HF = heart failure

# Postextubation Recommendations

| Risk for re-intubation | Recommendations |
| --- | --- |
| Low | No indication |
| High | |
| Need ventilatory assistance | NIV |
| *Hypoxemic need high PEEP | CPAP |
| Hypoxemic doesn't need high PEEP | HFNC |

*: (obese, abdominal surgery, significant atelectasis)

Respir Care 2019;64(6):658–678.

# Recommendations

- **We suggest that NIV be used to prevent post-extubation respiratory failure in high-risk patients post-extubation.** (Conditional recommendation, low certainty of evidence.)
- **We suggest that NIV should not be used to prevent post-extubation respiratory failure in non-high-risk patients.** (Conditional recommendation, very low certainty of evidence.)

# Recommendation

- **We suggest that NIV should not be used in the treatment of patients with established post-extubation respiratory failure.**
- (Conditional recommendation, low certainty of evidence.)

# SHOULD NIV BE USED IN DE NOVO ARF?

# De novo respiratory failure

- Respiratory failure occurring without prior chronic respiratory disease.
- Most patients are hypoxeamic respiratory failure

  -hypoxaemia ($PaO_2/FIO_2 \leqslant 200$)

  -tachypnea (RR >30 35 /min)
- Nearly three quarters of the cases are pneumonia
- 10-15% of patients with de novo acute respiratory failure or ARDS used NIV

# Limitation of NIV in de novo RF

- Lack of efficacy in reducing work of breathing
- Need sufficient pressure support
- High inspiratory demand → large transpulmonary pressures → large tidal volumes → VILI
- High inspiratory pressure → increase air leaks, gastric insufflation and patient intolerance
- Difficult for low tidal volume
- Spontaneous ventilation → VILI in severe lung injury

# Official ERS/ATS clinical practice guidelines: noninvasive ventilation for acute respiratory failure

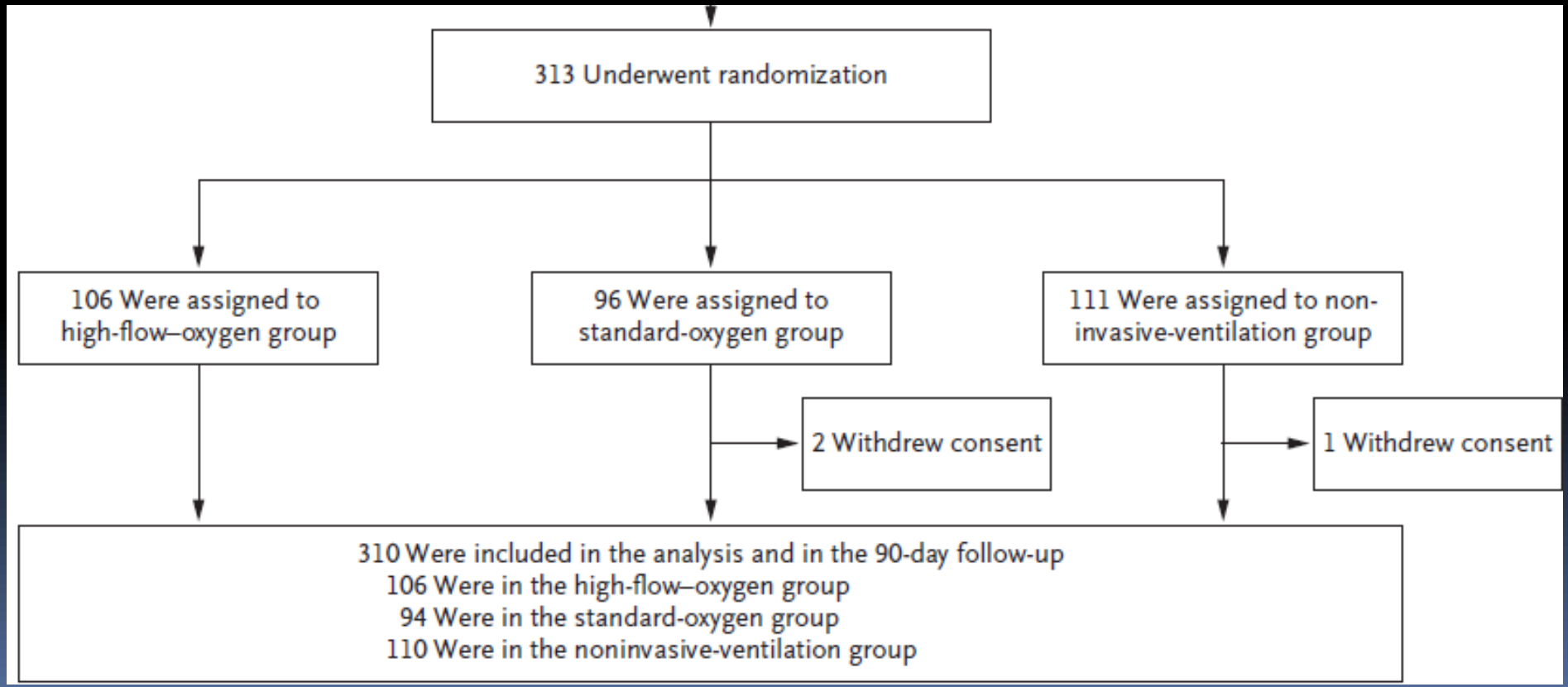
Bram Rochwerg[1], Laurent Brochard[2,3], Mark W. Elliott[4], Dean Hess[5], Nicholas S. Hill[6], Stefano Nava[7] and Paolo Navalesi[8] (members of the steering committee); Massimo Antonelli[9], Jan Brozek[1], Giorgio Conti[9], Miquel Ferrer[10], Kalpalatha Guntupalli[11], Samir Jaber[12], Sean Keenan[13,14], Jordi Mancebo[15], Sangeeta Mehta[16] and Suhail Raoof[17,18] (members of the task force)

- NIV in patients with de novo respiratory failure remains debated
- No recommendations for its use in this setting

The NEW ENGLAND JOURNAL of MEDICINE

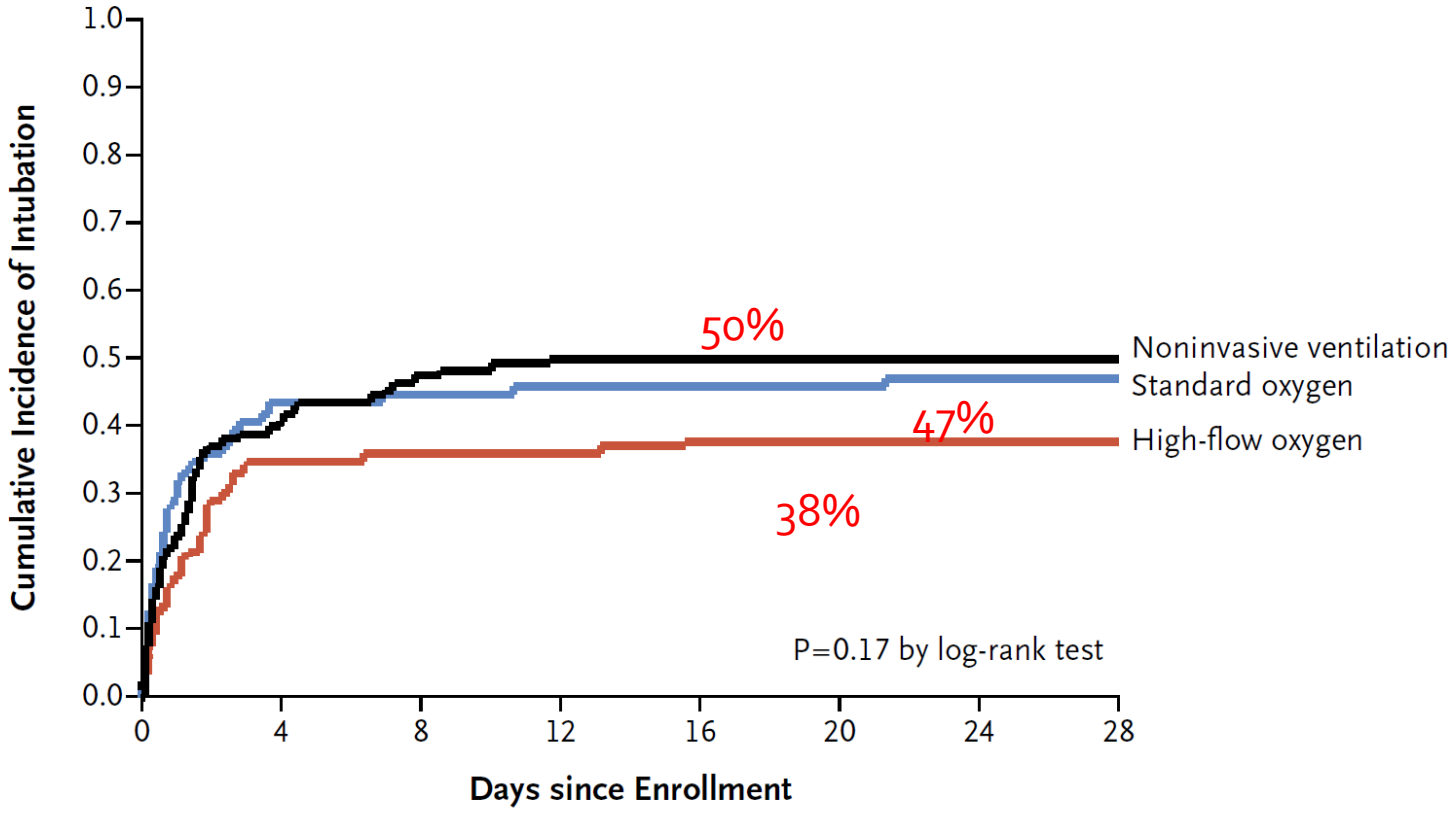
ORIGINAL ARTICLE

# High-Flow Oxygen through Nasal Cannula in Acute Hypoxemic Respiratory Failure



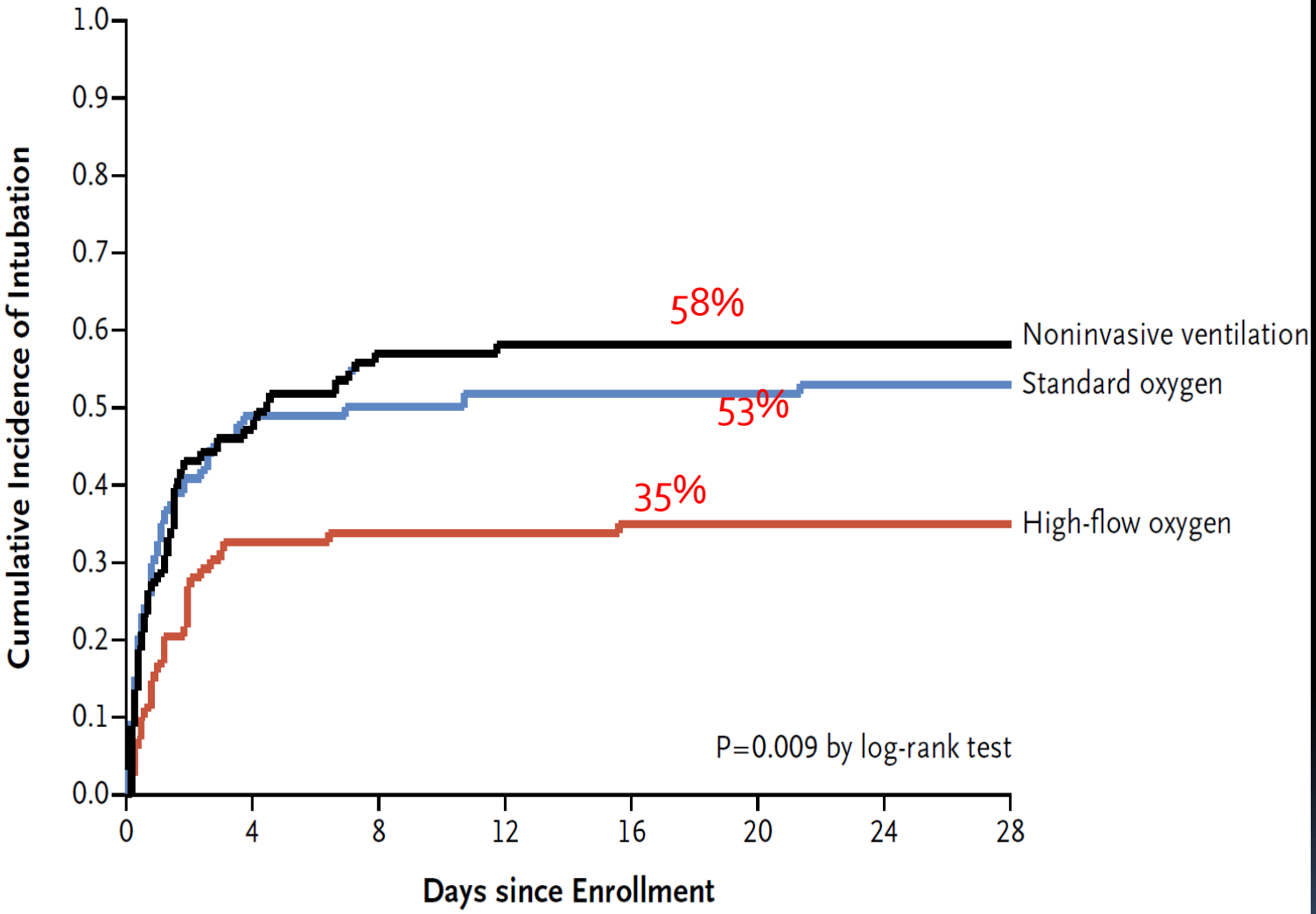
# Intubation rate

**A** **Overall Population**




| No. at Risk | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| High-flow oxygen | 106 | 68 | 67 | 67 | 65 | 65 | 65 | 65 |
| Standard oxygen | 94 | 52 | 50 | 49 | 49 | 49 | 48 | 48 |
| Noninvasive ventilation | 110 | 64 | 57 | 53 | 53 | 53 | 53 | 52 |

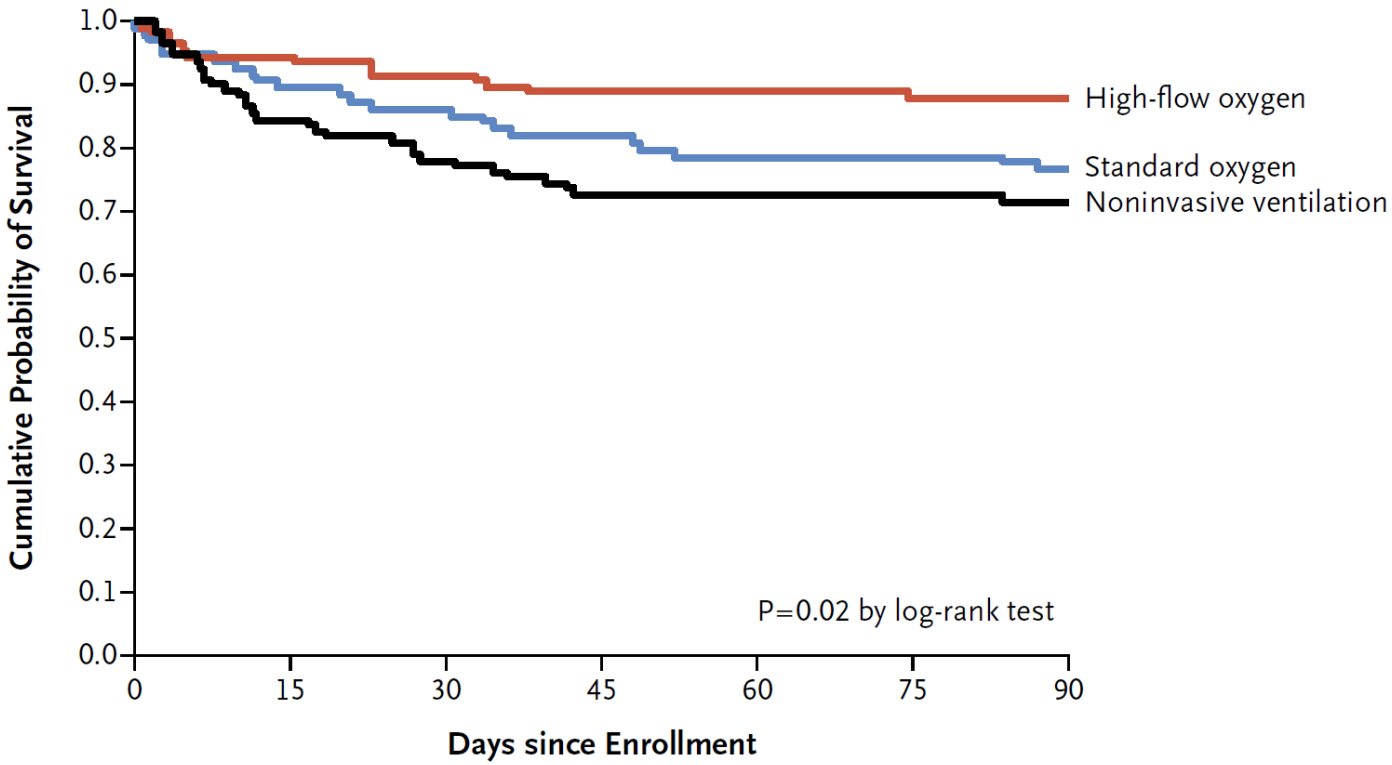
**B** Patients with a $Pao_2$:$FIo_2$ ≤200 mm Hg




**No. at Risk**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| High-flow oxygen | 83 | 55 | 54 | 54 | 53 | 53 | 53 | 53 |
| Standard oxygen | 74 | 37 | 35 | 34 | 34 | 34 | 33 | 33 |
| Noninvasive ventilation | 81 | 41 | 34 | 32 | 32 | 32 | 32 | 32 |

# D90 Survival




**No. at Risk**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| High-flow oxygen | 106 | 100 | 97 | 94 | 94 | 93 | 93 |
| Standard oxygen | 94 | 84 | 81 | 77 | 74 | 73 | 72 |
| Noninvasive ventilation | 110 | 93 | 86 | 80 | 79 | 78 | 77 |

**Figure 3. Kaplan–Meier Plot of the Probability of Survival from Randomization to Day 90.**

# Predictors of Intubation in Patients With Acute Hypoxemic Respiratory Failure Treated With a Noninvasive Oxygenation Strategy*

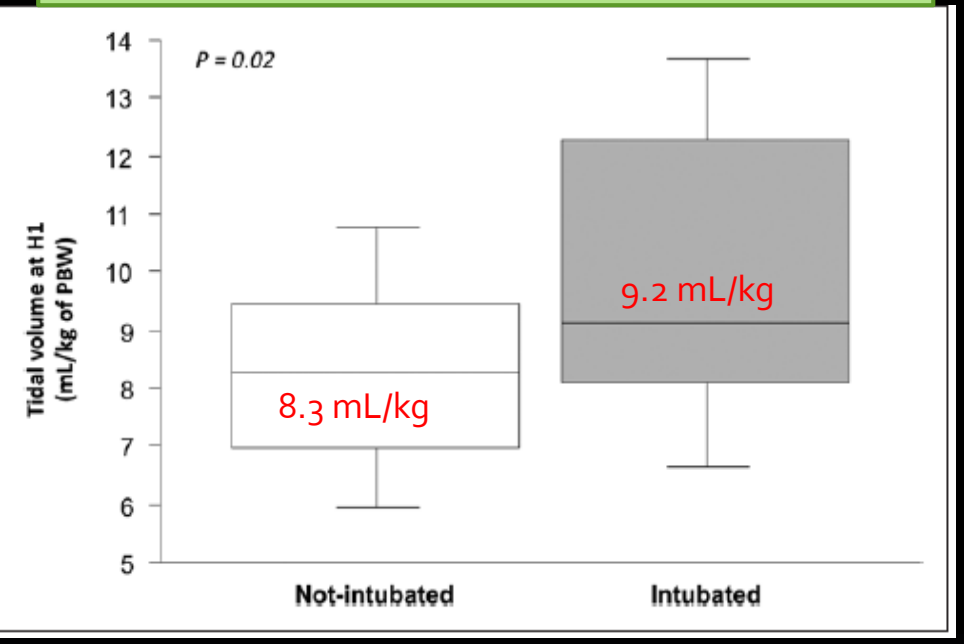
Jean-Pierre Frat, MD[1,2,3]; Stéphanie Ragot, PhD[4,5,6]; Rémi Coudroy, MD[1,2,3]; Jean-Michel Constantin, PhD[7]

**TABLE 3. Multivariate Logistic Regression Analyses of Factors Associated With Intubation**

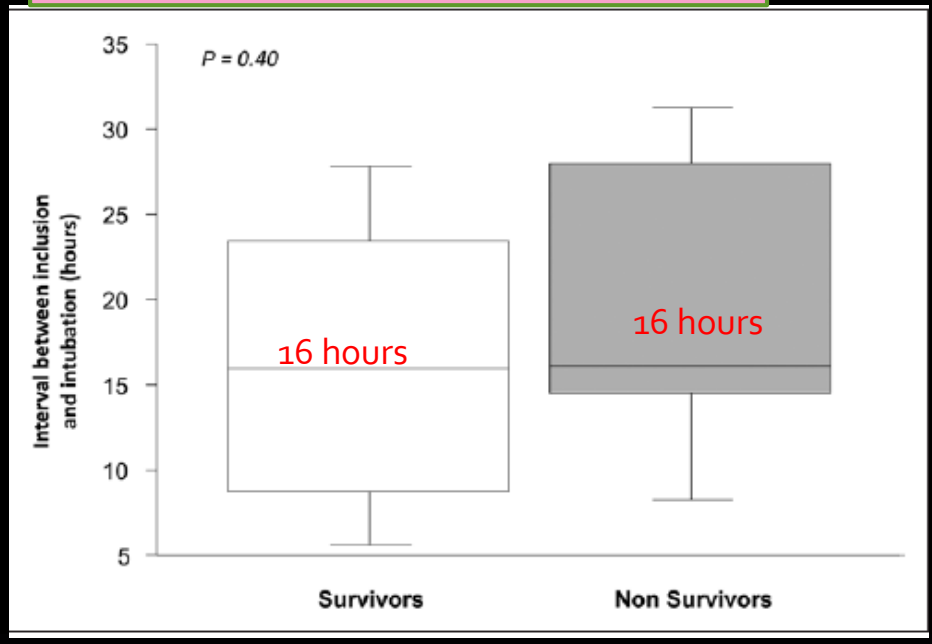
| Risk Factors | OR (95% CI) | *p* |
|---|---|---|
| In patients treated with conventional $O_2$ therapy by nonrebreathing mask[a] | | |
| Respiratory rate ≥ 30 breaths/min at H1 | 2.76 (1.13–6.75) | 0.03 |
| In patients treated with high-flow nasal cannula oxygen therapy[a] | | |
| Heart rate at H1 (per beat/min) | 1.03 (1.01–1.06) | < 0.01 |
| In patients treated with noninvasive ventilation[ab] | | |
| Tidal volume > 9 mL/kg of predicted body weight at H1 | 3.14 (1.22–8.06) | 0.02 |
| $Pao_2/Fio_2$ ≤ 200 mm Hg at H1 | 4.26 (1.62–11.16) | 0.003 |

Crit Care Med 2018; 46:208–215

# Tidal Volume




# Interval before intubation




✓ Predictors of intubation : TV>9 ml/Kg ; PF ratio < 200

✓ Poor outcomes were not because of delayed intubation

ORIGINAL ARTICLE

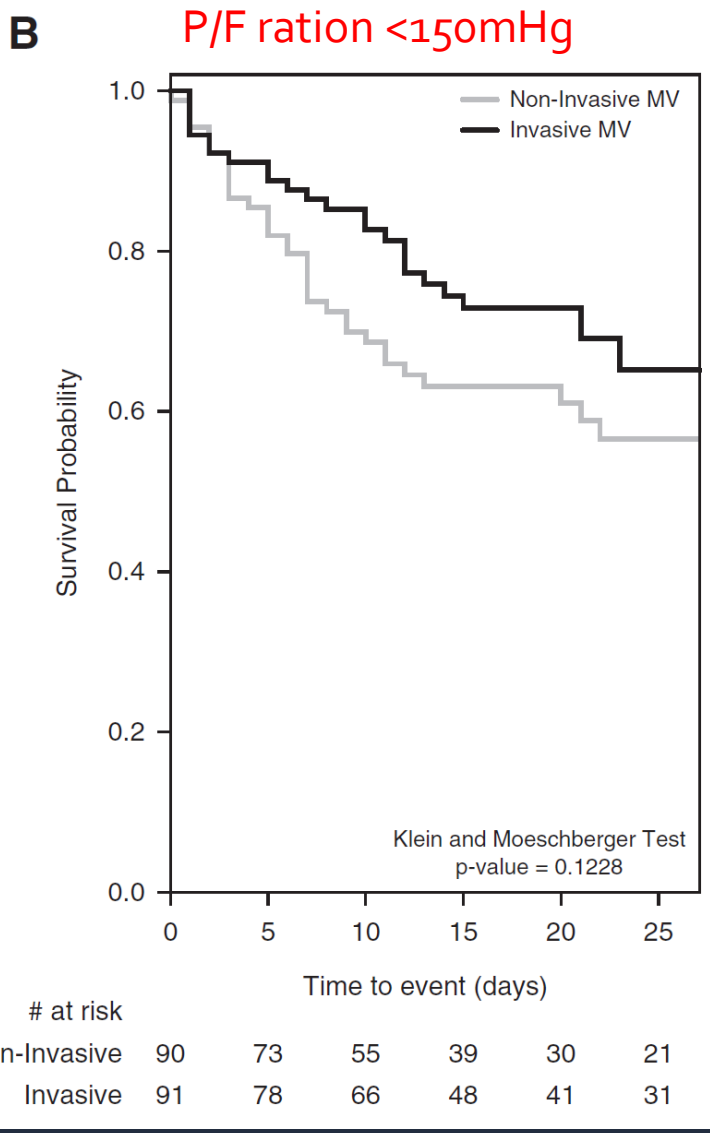
**Noninvasive Ventilation of Patients with Acute Respiratory Distress Syndrome**

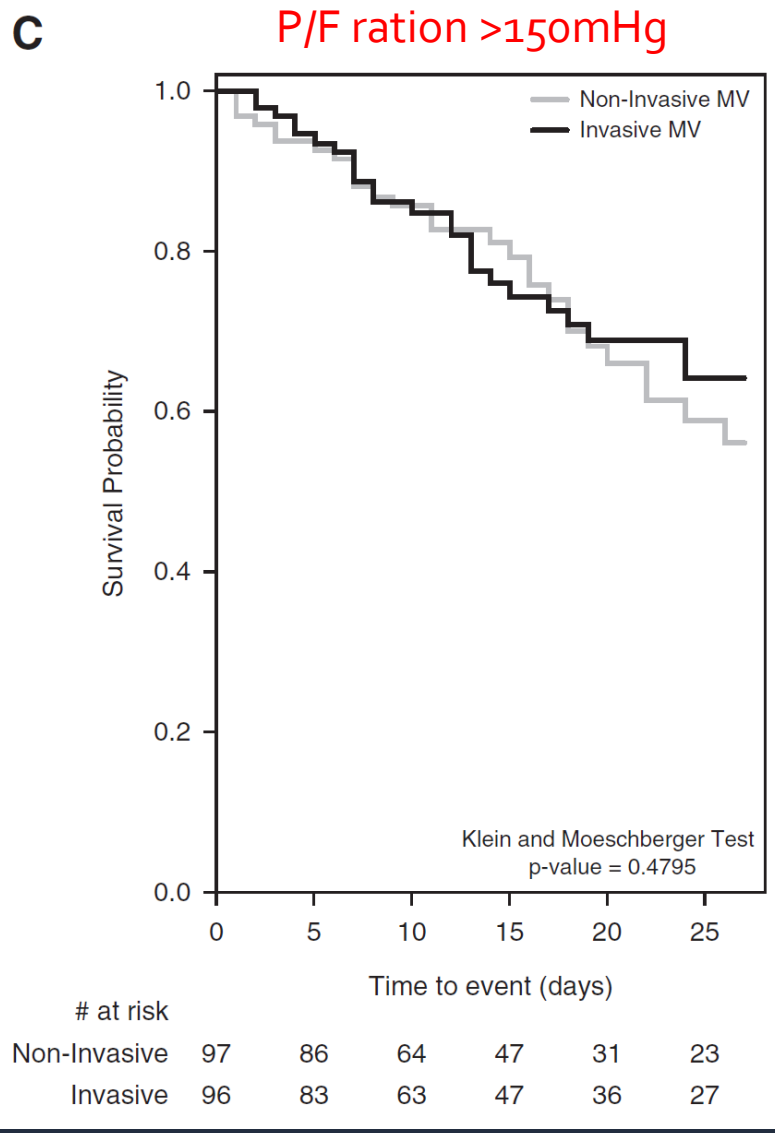
Insights from the LUNG SAFE Study

Giacomo Bellani[1,2], John G. Laffey[3,4,5,6,7,8], Tài Pham[9,10,11], Fabiana Madotto[12], Eddy Fan[8,13,14,15],

- NIV was used in 15% of ARDS patients
- NIV failure rate : 22.2% of mild, 42.3% of moderate, and 47.1% of severe ARDS

Am J Respir Crit Care Med 2017; 195




Higher ICU mortality in patients with a $PaO_2/FIO_2$ lower than 150 mm Hg received NIV than invasive-MV

Am J Respir Crit Care Med 2017; 195

Table 2. Risk Factors and Mortality Risk Associated With NIV

| Parameter | Value | Reference(s) |
|---|---|---|
| Risk factor | | |
| $P_{aO_2}/F_{IO_2}$, mm Hg | <150 | Antonelli et al,[21] Bellani et al,[23] Carrillo et al,[24] Demoule et al[22] |
| Severity scores | SAPS II ≥ 35, SOFA ≥ 7, APACHE II* | Antonelli et al,[21] Carrillo et al[24] |
| Tidal volume, mL/kg | >9 | Carteaux et al,[28] Frat et al[25] |
| Age, y | >40 | Antonelli et al[21] |
| Etiology | CAP, ARDS, immunosuppression | Antonelli et al,[21] Bellani et al,[23] Demoule et al,[22] Carteaux et al[28] |
| Score | HACOR > 5 | Duan et al[34] |
| Mortality risk | | |
| Severity scores | SAPS II > 47, SOFA ≥ 12, APACHE II† | Carrillo et al,[24] Demoule et al[22] |
| Delayed intubation | >12 h | Duan et al[34] |
| NIV failure | Required intubation | Rodriguez et al,[35] Duan et al,[34] Demoule et al[22] |
| Score | HACOR > 5 | Duan et al[34] |
| Age, y | >64 y | Demoule et al[22] |

* Median 14 vs 17 (success vs failure).
† Median 15 vs 19 (survivors vs nonsurvivors).

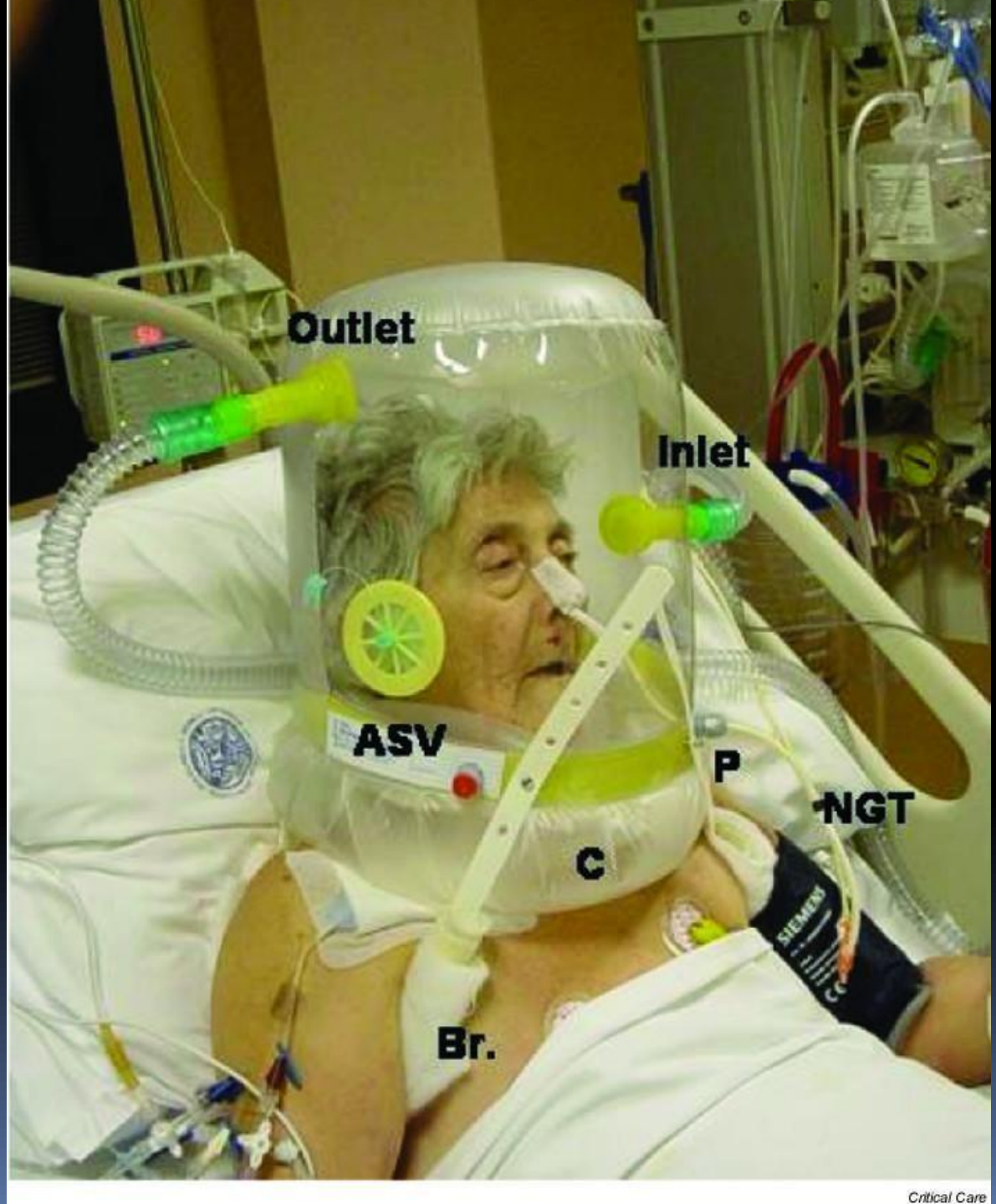
Table 3. HACOR Score

| Parameter | HACOR Score |
|---|---|
| Heart rate | |
| ≤120 beats/min | 0 |
| ≥121 beats/min | 1 |
| pH | |
| ≥7.35 | 0 |
| 7.30–7.34 | 2 |
| 7.25–7.29 | 3 |
| <7.25 | 4 |
| Glasgow coma scale score | |
| 15 | 0 |
| 13–14 | 2 |
| 11–12 | 5 |
| ≤10 | 10 |
| $P_{aO_2}/F_{IO_2}$ | |
| ≥201 mm Hg | 0 |
| 176–200 mm Hg | 2 |
| 151–175 mm Hg | 3 |
| 126–150 mm Hg | 4 |
| 101–125 mm Hg | 5 |
| ≤100 mm Hg | 6 |
| Frequency | |
| ≤30 breaths/min | 0 |
| 31–35 breaths/min | 1 |
| 36–40 breaths/min | 2 |
| 41–45 breaths/min | 3 |
| ≥46 breaths/min | 4 |

When receiving NIV for hypoxemic respiratory failure, a HACOR score of >5 at 1 h of NIV predicted failure.
HACOR = heart rate, acidosis, consciousness, oxygenation, and respiratory rate
NIV = noninvasive ventilation

# Trial of NIV may be offered

- Community-acquired pneumonia or early ARDS managed by an experienced clinical team
- Carefully selected (no contraindications such as abnormal mental status, shock or multiorgan system failure)
- Closely monitored in the ICU
- Reassessed early after starting NIV
- Intubated promptly if they are not improving.




*Critical Care* 20049:98

# Helmet

- ability to deliver and maintain higher levels of PEEP
- improved patient tolerance
- longer sessions of NIV

Preliminary Communication | CARING FOR THE CRITICALLY ILL PATIENT

# Effect of Noninvasive Ventilation Delivered by Helmet vs Face Mask on the Rate of Endotracheal Intubation in Patients With Acute Respiratory Distress Syndrome

## A Randomized Clinical Trial

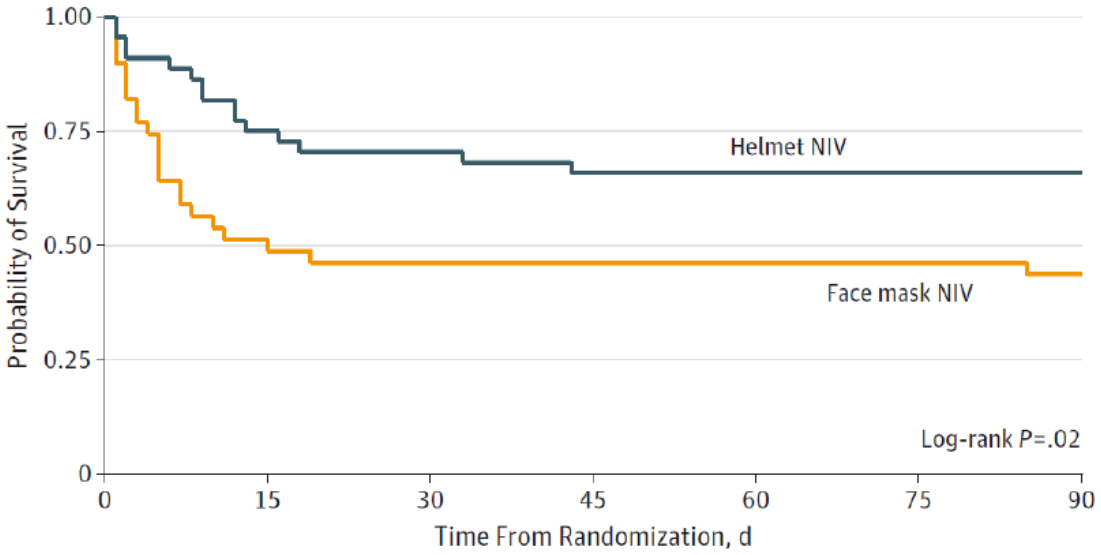
Bhakti K. Patel, MD; Krysta S. Wolfe, MD; Anne S. Pohlman, MSN; Jesse B. Hall, MD; John P. Kress, MD

- A single-center, randomized clinical trial
- 83 patients were enrolled (39 facemask; 44 helmet)
- Pneumonia was the major cause
- P/F: 144 in facemask; 118 in helmet group

*JAMA. 2016;315(22)*

# D90 Survival

Figure 2. Probability of Survival From Randomization to Day 90




| No. at risk | | | | | | | |
|---|---|---|---|---|---|---|---|
| Face mask | 39 | 20 | 18 | 18 | 18 | 18 | 17 |
| Helmet | 44 | 33 | 31 | 29 | 29 | 29 | 29 |

*JAMA. 2016;315(22)*

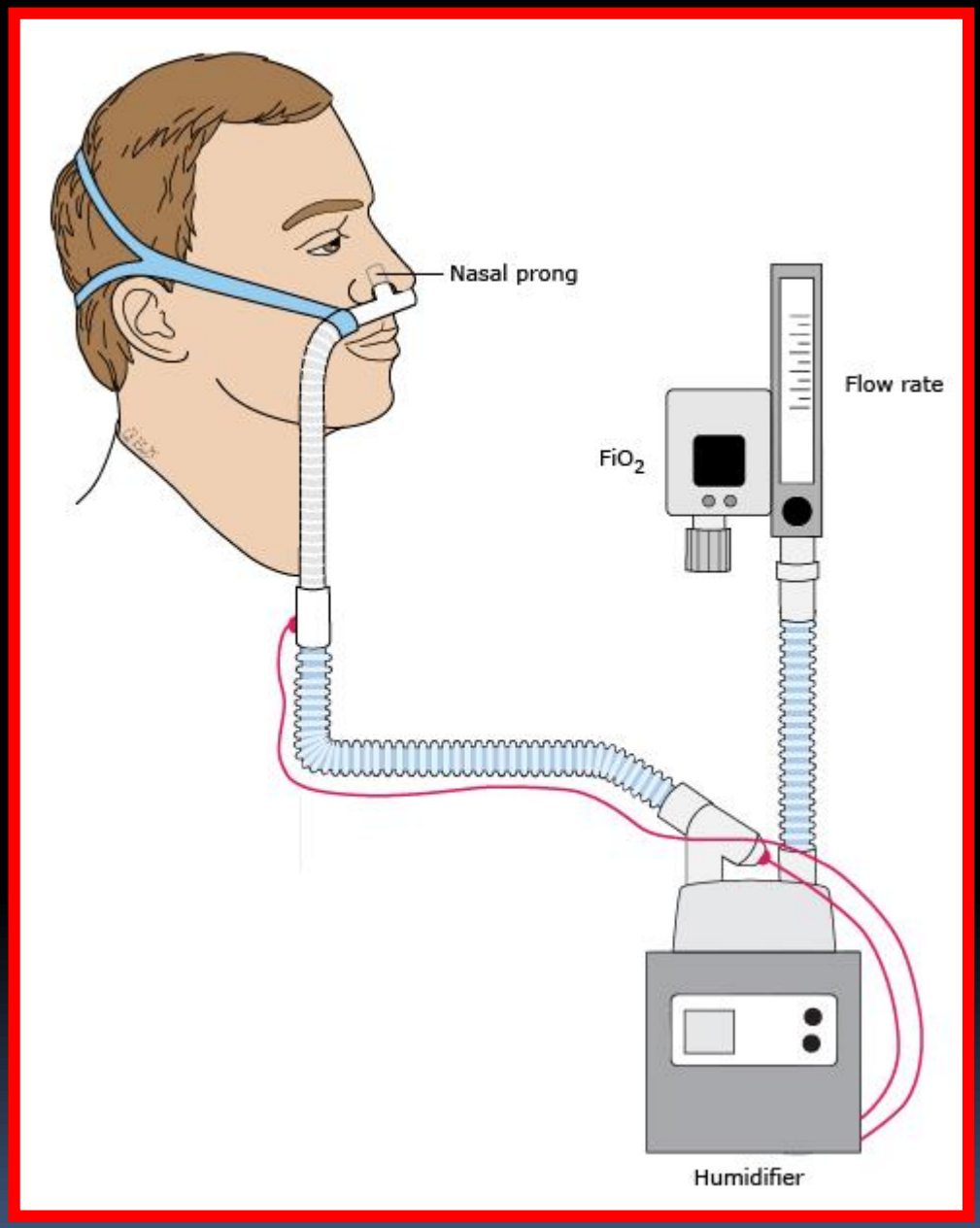
# Recommendation

- **Given the uncertainty of evidence we are unable to offer a recommendation on the use of NIV for de novo ARF.**

# High Flow Nasal Cannula (HFNC)的原理與臨床運用

# High flow nasal cannula

- 急性呼吸衰竭患者產生的吸氣峰值平均值為30-40 L/min，更嚴重的可達到120 L / min
- 傳統氧療設備如nasal cannula, simple mask, Venturi mask, and non-rebreathing mask provide a maximum oxygen flow of 6－15 l/min
- 吸入氧氣與室內空氣混合，從而減小FiO2，其FiO2 通常不超過0.7
- High-flow nasal cannula (HFNC) deliver up to 100 % heated and humidified oxygen via a wide-bore nasal cannula at a maximum flow of 60 l/min




A typical set up for oxygen delivery through high flow nasal cannulae.

# HFNC作用機轉

- 加熱和加濕增強舒適度
- 增加粘液的含水量促進分泌物去除，避免乾燥和上皮損傷
- 呼吸代謝成本降低，減少呼吸工作
- 高流量氧氣減少空氣的吸入;提高$FIO_2$
- 清除上呼吸道死腔中CO2，提高通氣效率
- 提供呼氣末正壓(PEEP)
- recruitment of alveoli→increase FRC→減少呼吸作工

CHEST 2015; 148(1):253-261

# 等溫飽和邊界(Isothermic saturation boundary ，ISB)

- 空氣在肺部達到37℃和100%相對濕度（RH）的位置
- 通常位於Carina附近。
- 吸入乾燥空氣使ISB向下移動至支氣管
- 氣道粘膜脫水，纖毛功能受損，分泌物無法排除
- 部分或完全氣道阻塞
- 肺炎發生率增加

+34 cc

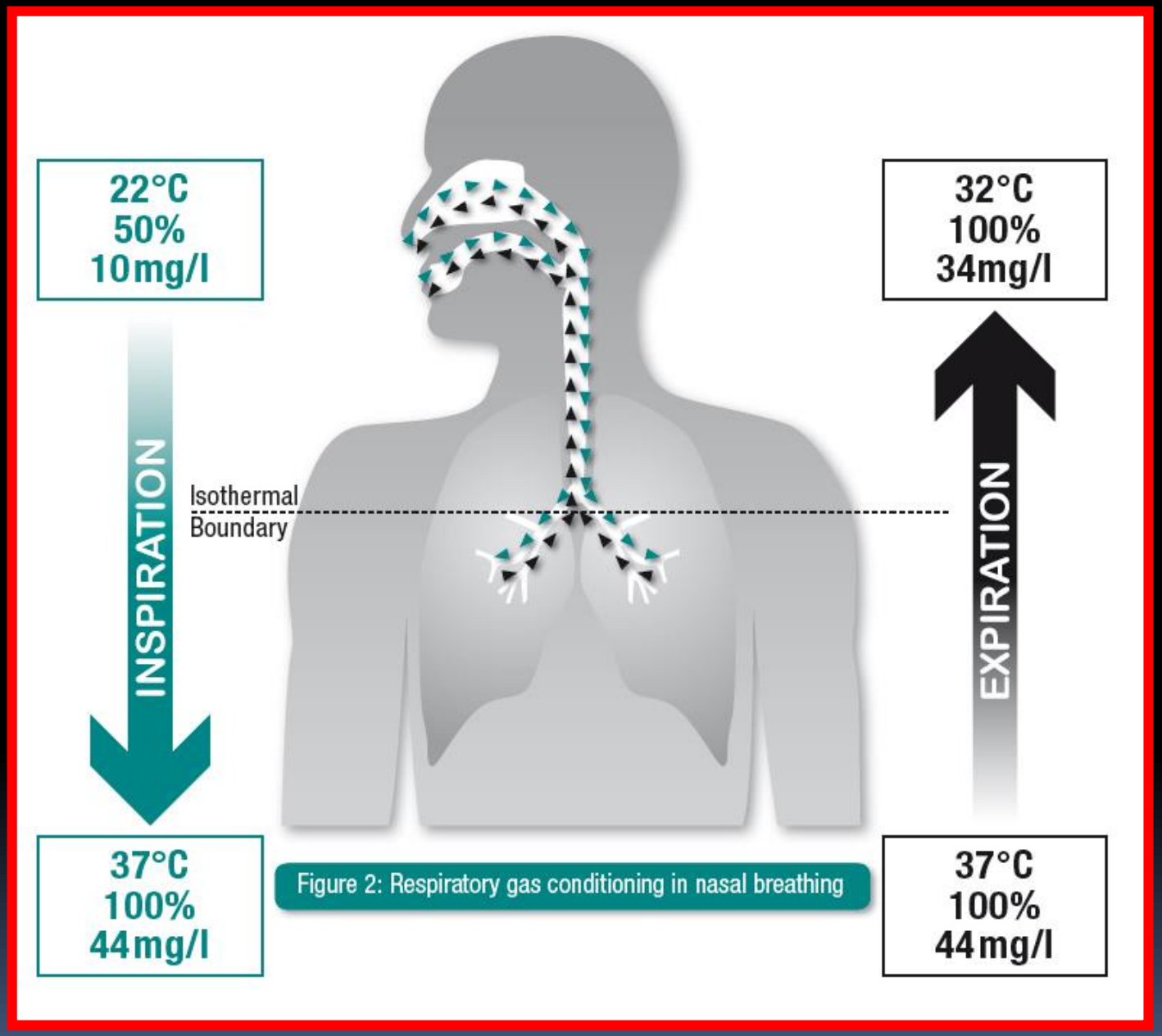


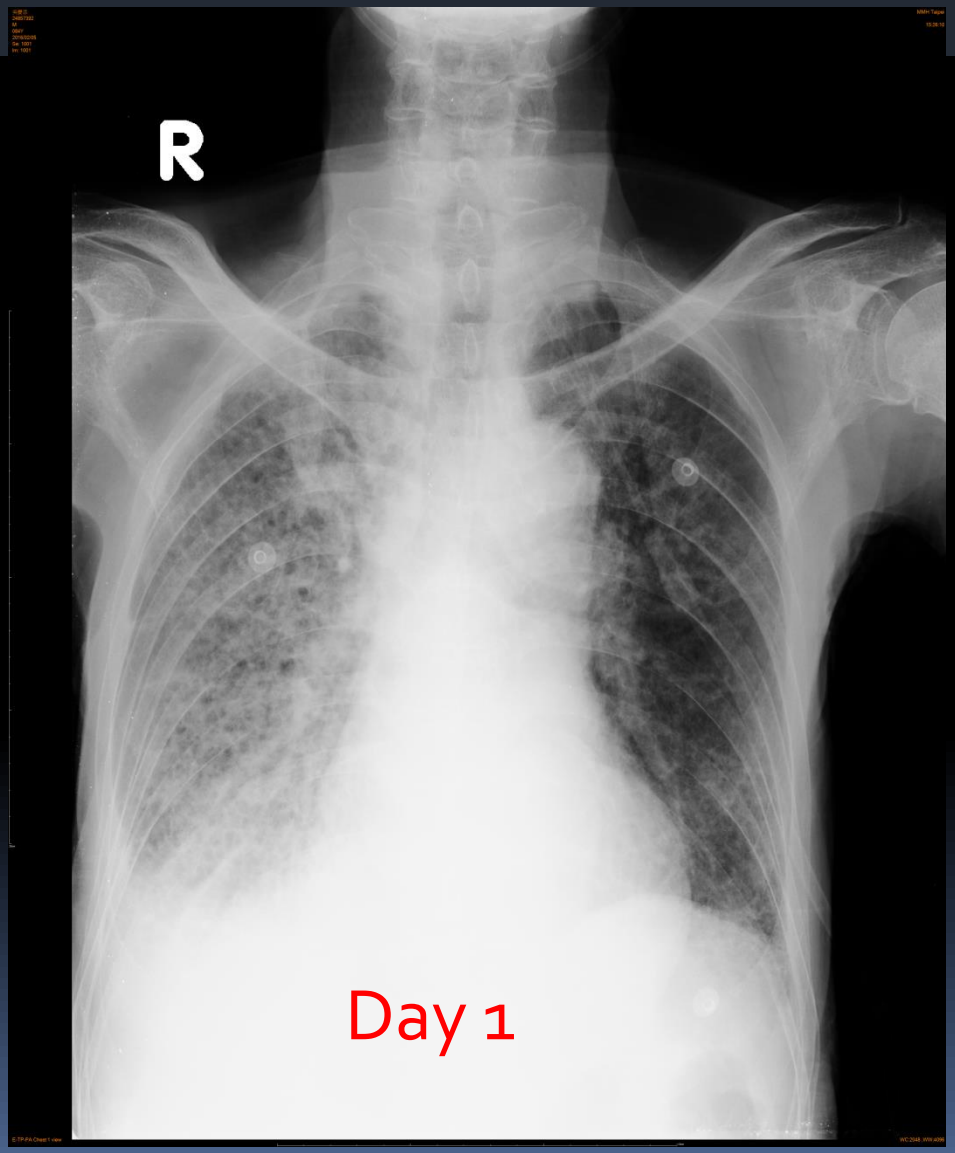

Figure 2: Respiratory gas conditioning in nasal breathing

-10cc

Shelly MP, et al.. *Intensive Care Med 1988, 14:1-9.*

# 84 y/o male

**#1. CHF with AE**
**#2. COPD**
**#3. CAD with TVD**
**#4.Pneumonia**



# The Effects of Gas Humidification with High-Flow Nasal Cannula on Cultured Human Airway Epithelial Cells

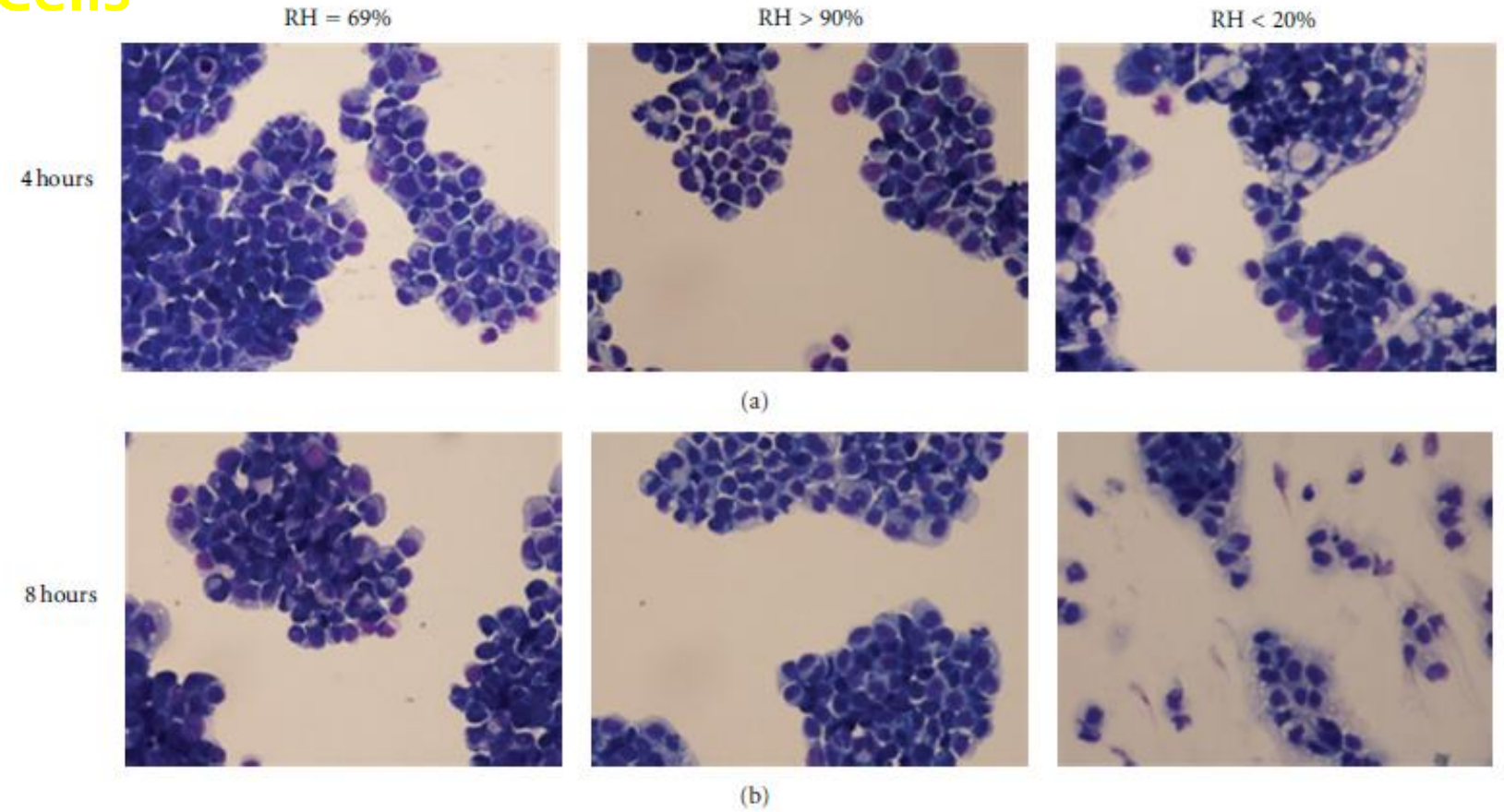



FIGURE 6: Cytomorphological examination of Calu-3 cell monolayers exposed to one of three levels of relative humidity: <20% (dry), 69% (noninterventional comparator), and >90% (HFNC). Representative cytomorphological examination of Calu-3 cells for both the noninterventional comparator group and the HFNC group demonstrated normal morphology. At 4 and 8 hours, the dry group showed abnormal cellular appearances, swollen nuclei, intracellular and nuclear vacuoles, diffused cytoplasm, and cellular debris. All cytospins were examined by light microscopy at 40x magnification.

A Chidekel, Pulm Med, 2012 (2012), p. 380686

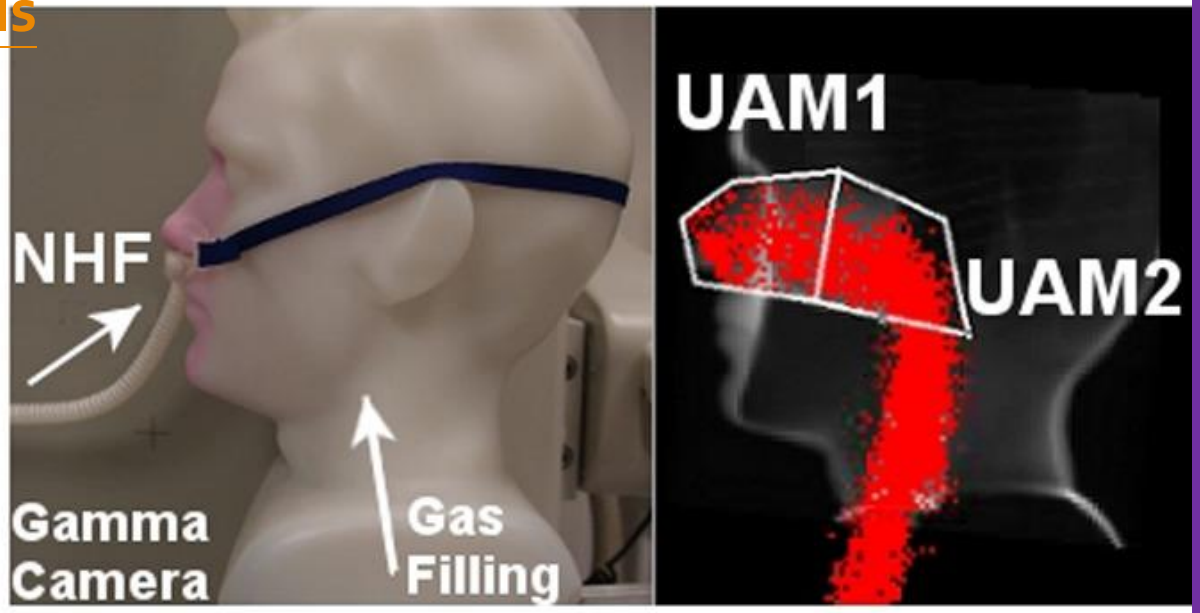
# 舉例:21 ℃ and 50% RH (9 mg water/L)

- 每升氣體需升高16℃(達到37℃)
- 每升氣體蒸發掉35毫克水分以達RH:100% ，需消耗26卡路里
- VT：500ml，RR：12次呼吸/分鐘
- 需消耗156卡路里/分鐘，9千卡/小時，225 千卡/天

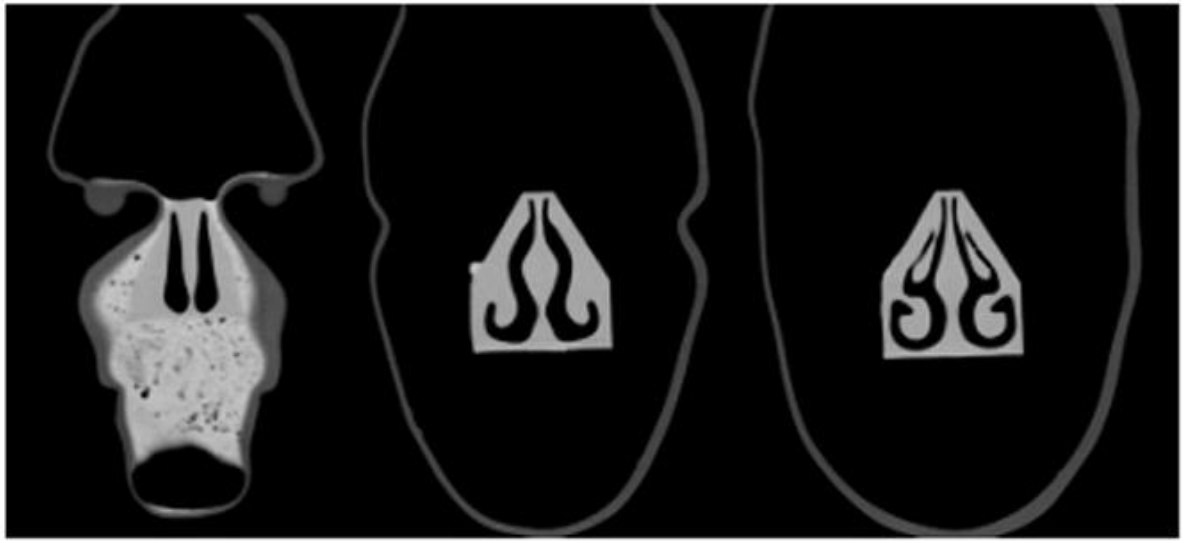
| Device | $FiO_2$ | $O_2$ Flow | Temperature | Humidity |
|---|---|---|---|---|
| Nasal Cannula | 24% - 44% | 1- 6 L/min | 15°C - 22°C<br>無加熱式 | 30% - 40%<br>濕化能力差 |
| Simple Mask | 35% - 50% | 5 - 10 L/min | 15°C - 22°C<br>無加熱式 | 30% - 40% |
| Aerosol Mask | 28% - 100% | 6 - 15 L/min | 22°C - 26°C<br>可附加hot plate加熱棒加熱 | 26 mg/L - 35mg/L absolute humidity, AH(加熱後 33mg/L - 55mg/L) |
| Venturi Mask | 24% - 90% | 4 - 15 L/min | 33°C - 41°C<br>可附加熱作用視濕化器種類而定 | 100%<br>relative humidity, RH |
| NRM (non - rebreathing mask) | 60% - 80% | 10 - 15 L/min | 15°C - 22°C<br>無加熱式 | 30% - 40% |
| BiPAP | 21% - 80% | 1- 15 L/min | 23.9°C - 29.4°C | 視濕化器種類而定，濕化能力差 |

# Nasal high flow clears anatomical dead space in upper airway models

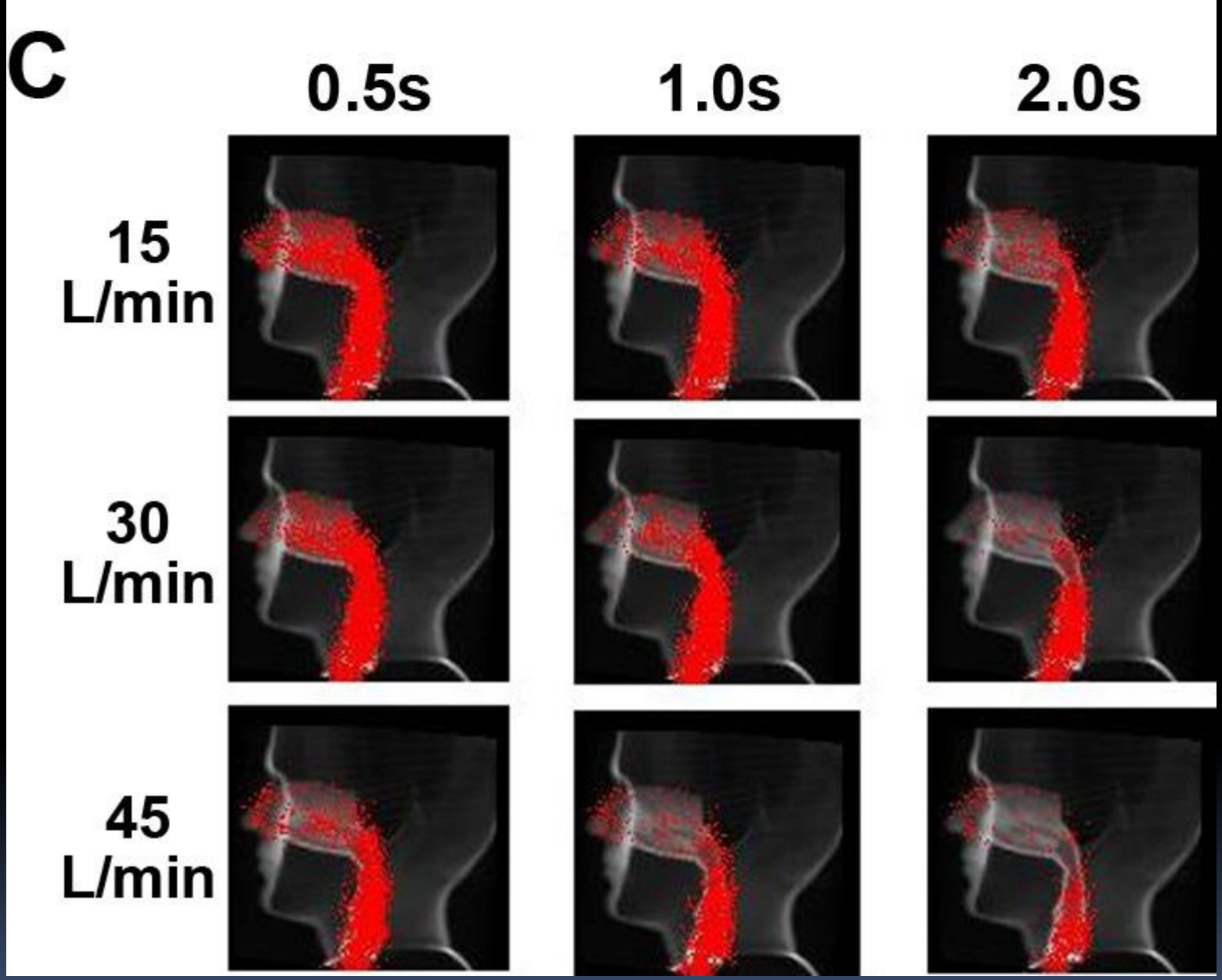
A




B



J Appl Physiol . 2015 June 15; 118(12): 1525–1532.




Winfried Möller, *et al.* J Appl Physiol . 2015 June 15; 118(12): 1525–1532.

# Mean airway pressure increased in each increase of 10 L/min

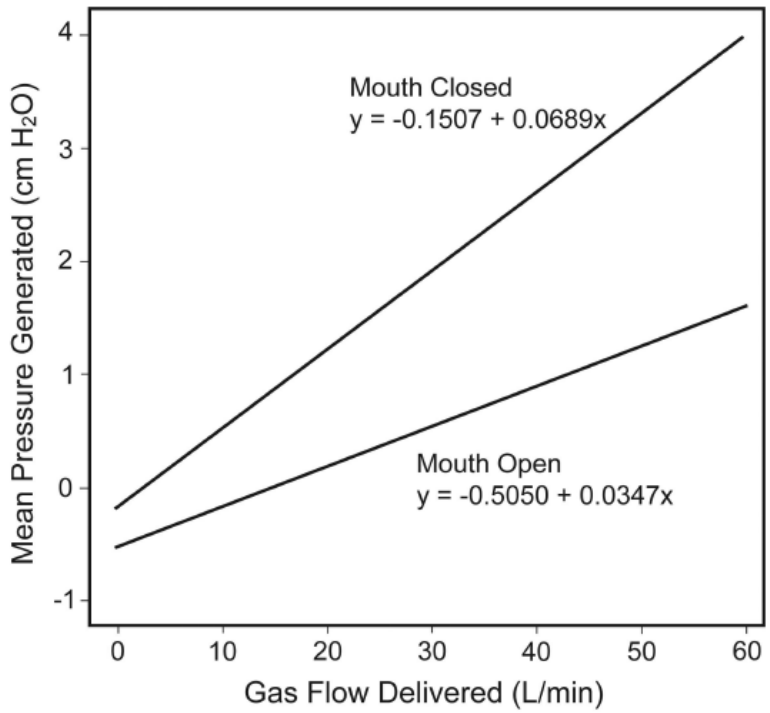



Fig. 3. Regression analysis of mean nasopharyngeal pressure during high-flow oxygen therapy, with mouth open or closed.

- 0.69 cm $H_2O$ ($P < .01$) when mouths closed
- 0.35 cm $H_2O$ ($P < .03$) when mouths open.

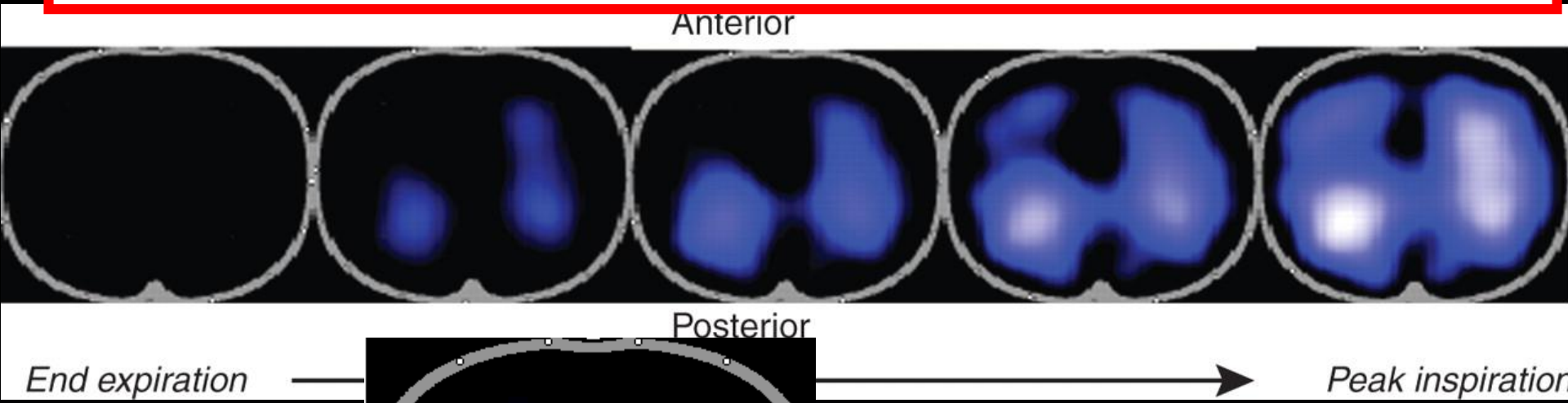
RL Parke, *et al.* Respiratory Care, 56 (8) (2011), pp. 1151–1155

*British Journal of Anaesthesia* **107** (6): 998–1004 (2011)
Advance Access publication 9 September 2011 · doi:10.1093/bja/aer265

BJA

# Oxygen delivery through high-flow nasal cannulae increase end-expiratory lung volume and reduce respiratory rate in post-cardiac surgical patients

A. Corley[1]*, L. R. Caruana[1], A. G. Barnett[2], O. Tronstad[1] and J. F. Fraser[1]




electrical impedance tomography（EIT，電阻抗斷層造影）

A. Corley et al. Br. J. Anaesth. 2011;107:998-1004

# HFNC vs low-flow oxygen

- increase in EELI (FRC) of 25.6%
- increased mean Paw by 3.0 cm $H_2O$
- Respiratory rate was lowered by 3.4 bpm
- Borg dyspnoea score by 0.8 points
- 10.5% increase of Vt
- $Pa_{O_2}/FI_{O_2}$ ratio was improved by 30.6

A. Corley et al. Br. J. Anaesth. 2011;107:998-1004

## Physiologic Effects of High-Flow Nasal Cannula in Acute Hypoxemic Respiratory Failure

Tommaso Mauri[1,2], Cecilia Turrini[1,3], Nilde Eronia[4], Giacomo Grasselli[1], Carlo Alberto Volta[3], Giacomo Bellani[4,5], and Antonio Pesenti[1,2]

[1]Department of Anesthesia, Critical Care and Emergency, IRCCS (Institute for Treatment and Research) Ca' Granda Maggiore Policlinico Hospital Foundation, Milan, Italy; [2]Department of Pathophysiology and Transplantation, University of Milan, Milan, Italy; [3]Department of Morphology, Surgery and Experimental Medicine, Section of Anesthesia and Intensive Care, University of Ferrara, Ferrara, Italy; [4]Department of Emergency, San Gerardo Hospital, Monza, Italy; and [5]Department of Medicine and Surgery, University of Milan-Bicocca, Monza, Italy

- **Less ΔPes ($P < 0.01$),** and pressure time product ($P < 0.001$).
- **minute ventilation was reduced ($P < 0.001$)** at constant arterial $CO_2$ tension and pH
- **end-expiratory lung volume increased ($P < 0.001$)**
- the **ratio of tidal volume to ΔPes** (an estimate of **dynamic lung compliance**) increased ($P < 0.05$)
- ventilation was more **homogeneous** ($P < 0.01$)

Mauri T,et al. Am J Respir Crit Care Med . 2017, Vol 195, Iss 9, pp 1207–1215

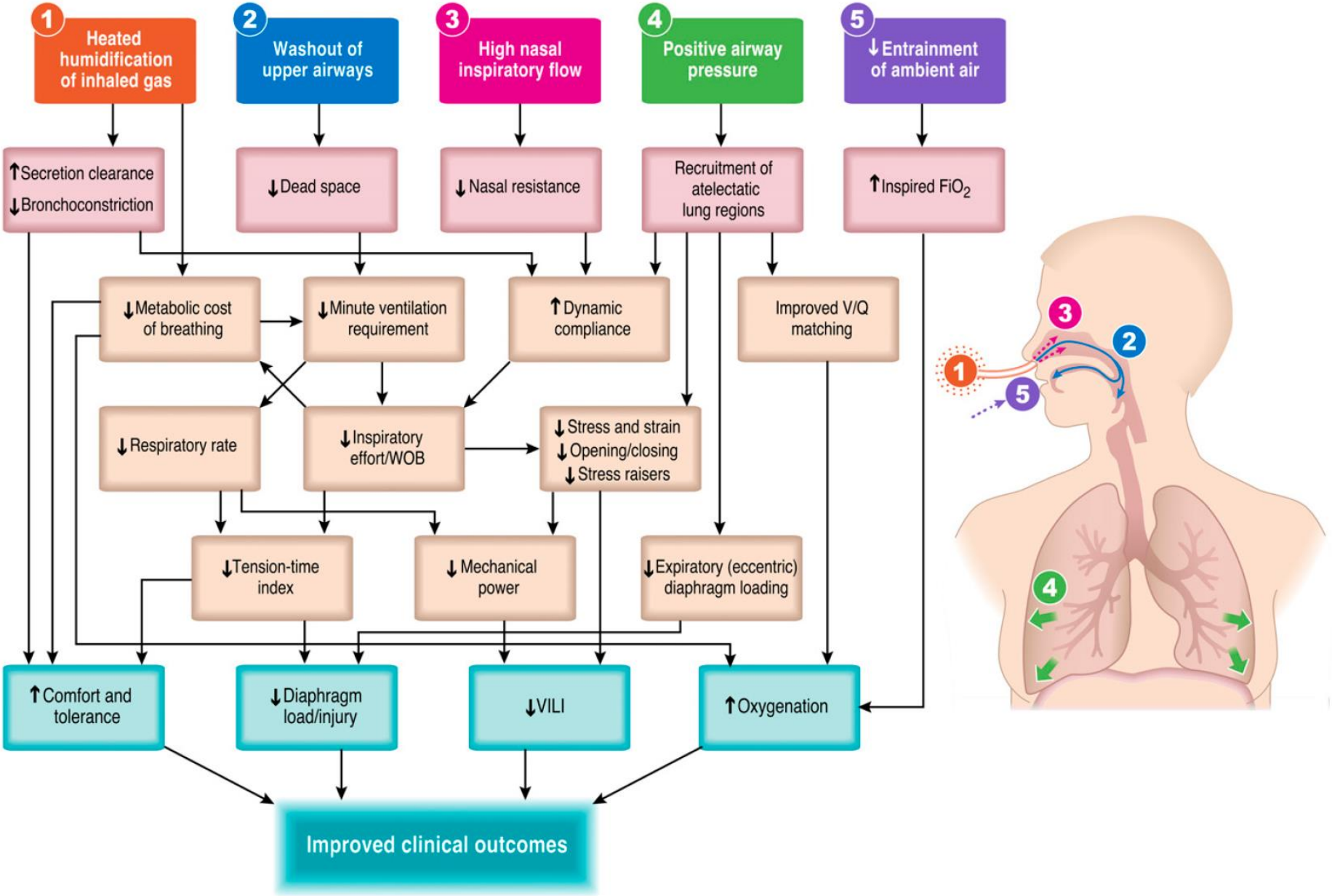
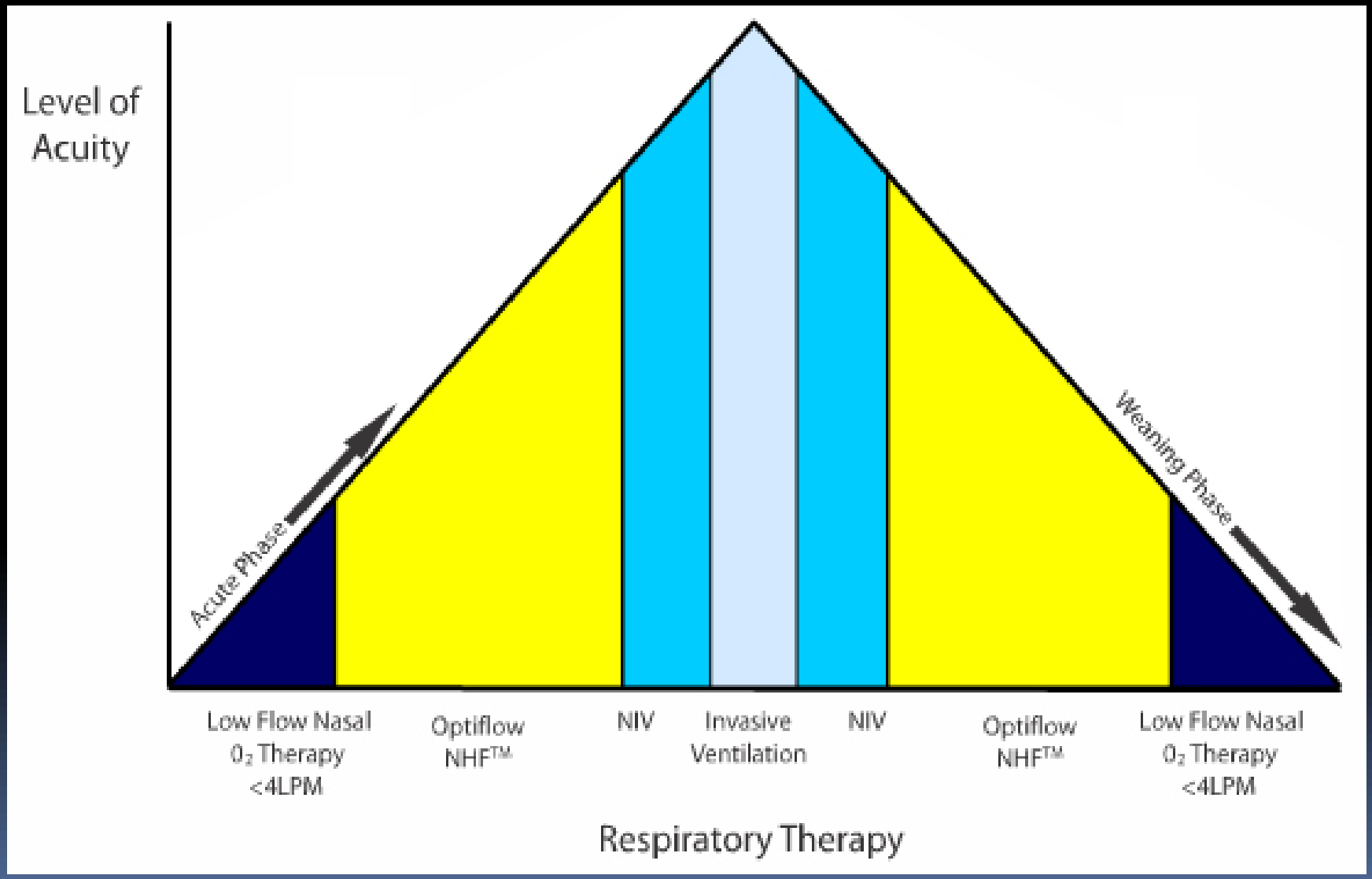


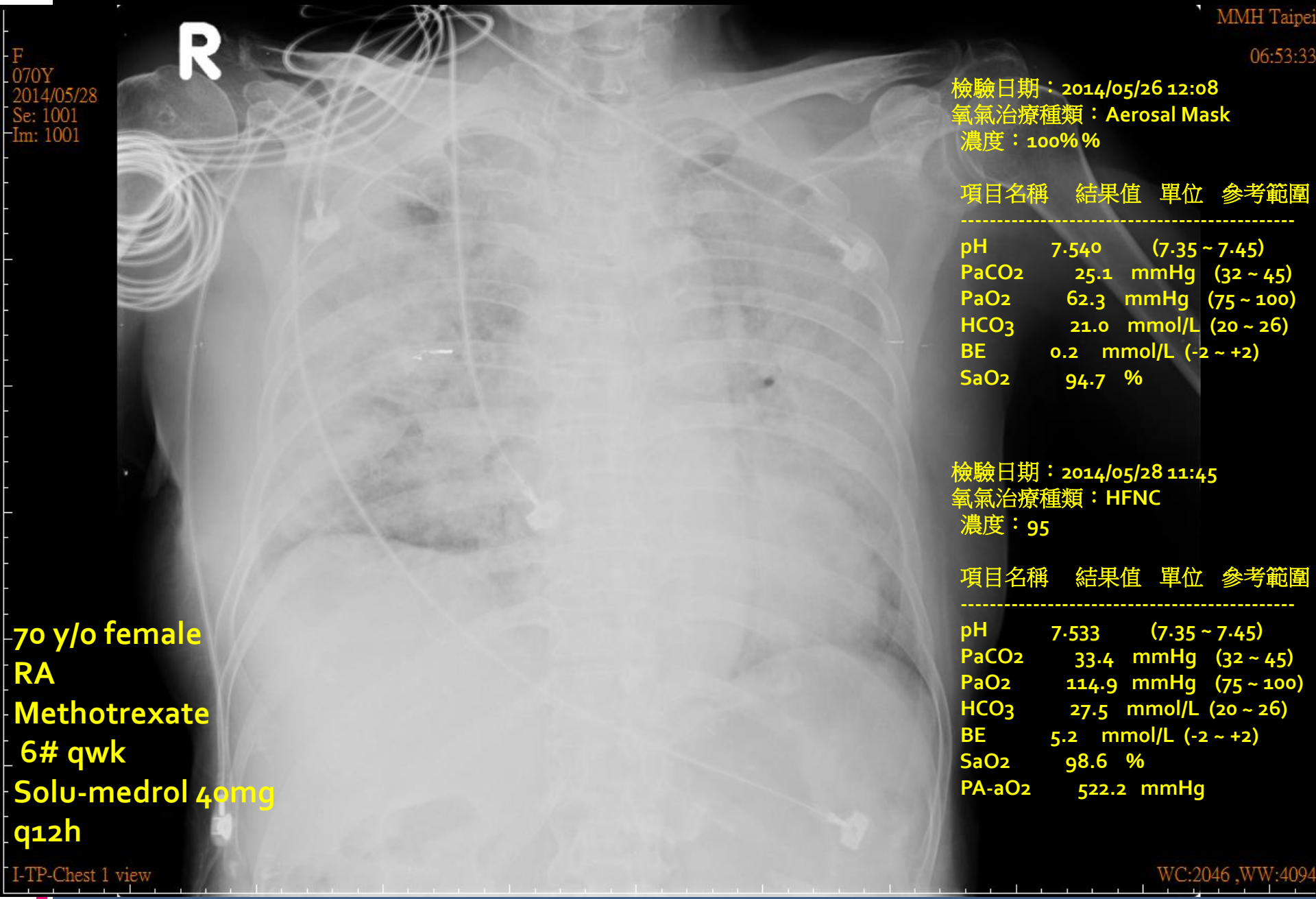

**Figure 1.** Mechanisms of action of high flow nasal cannula (HFNC) in acute hypoxemic respiratory failure. HFNC exerts a range of important and interdependent physiological effects on a variety of factors that may determine clinical outcomes for patients with acute respiratory failure. VILI = ventilator-induced lung injury; V/Q = ventilation/perfusion; WOB = work of breathing. Illustration by Jacqueline Schaffer.

# Where Does Optiflow™ NHF™ Fit?



# Clinical applications

- **Hypoxic respiratory failure**
- Immunocompromised patient
- Endotracheal intubation
- Emergent department
- Postextubation
- Postoperatively
- Cardiogenic pulmonary edema
- COPD
- Bronchoscope




檢驗日期：2014/05/26 12:08
氧氣治療種類：Aerosal Mask
濃度：100% %

| 項目名稱 | 結果值 | 單位 | 參考範圍 |
|---|---|---|---|
| pH | 7.540 | | (7.35 ~ 7.45) |
| $PaCO_2$ | 25.1 | mmHg | (32 ~ 45) |
| $PaO_2$ | 62.3 | mmHg | (75 ~ 100) |
| $HCO_3$ | 21.0 | mmol/L | (20 ~ 26) |
| BE | 0.2 | mmol/L | (-2 ~ +2) |
| $SaO_2$ | 94.7 | % | |

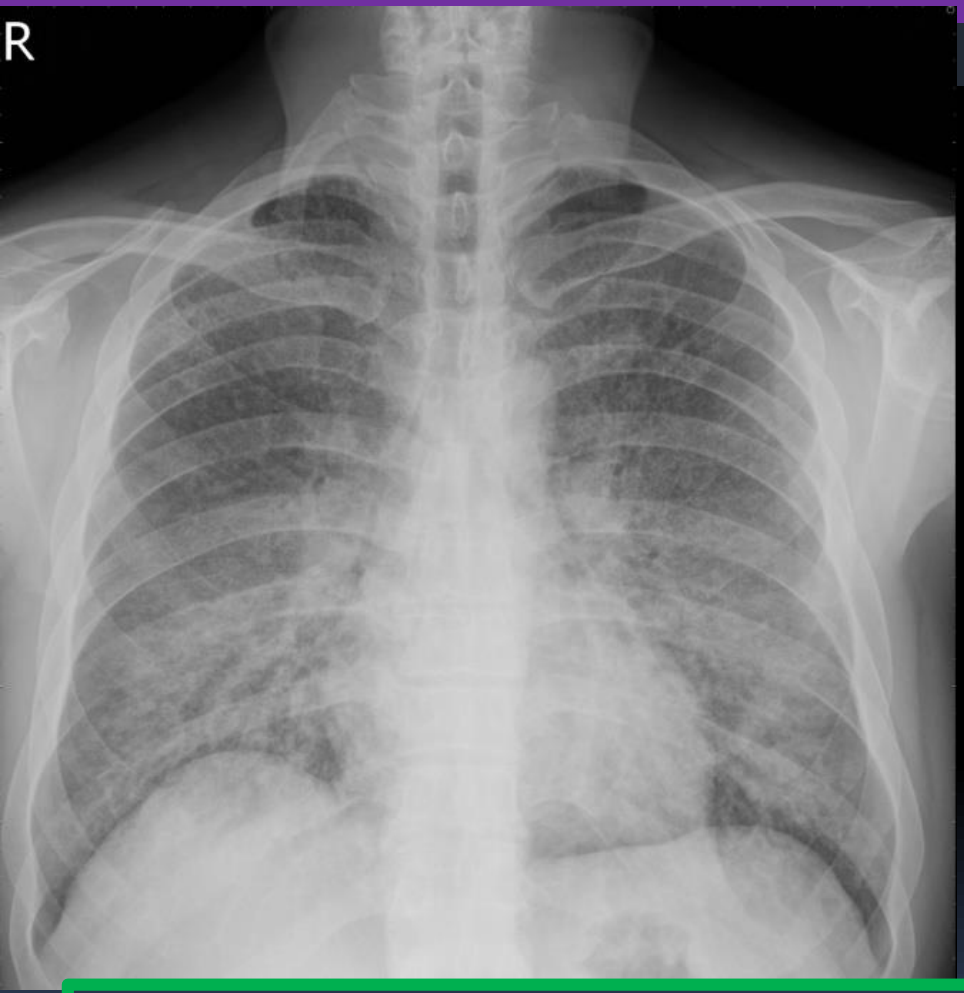
檢驗日期：2014/05/28 11:45
氧氣治療種類：HFNC
濃度：95

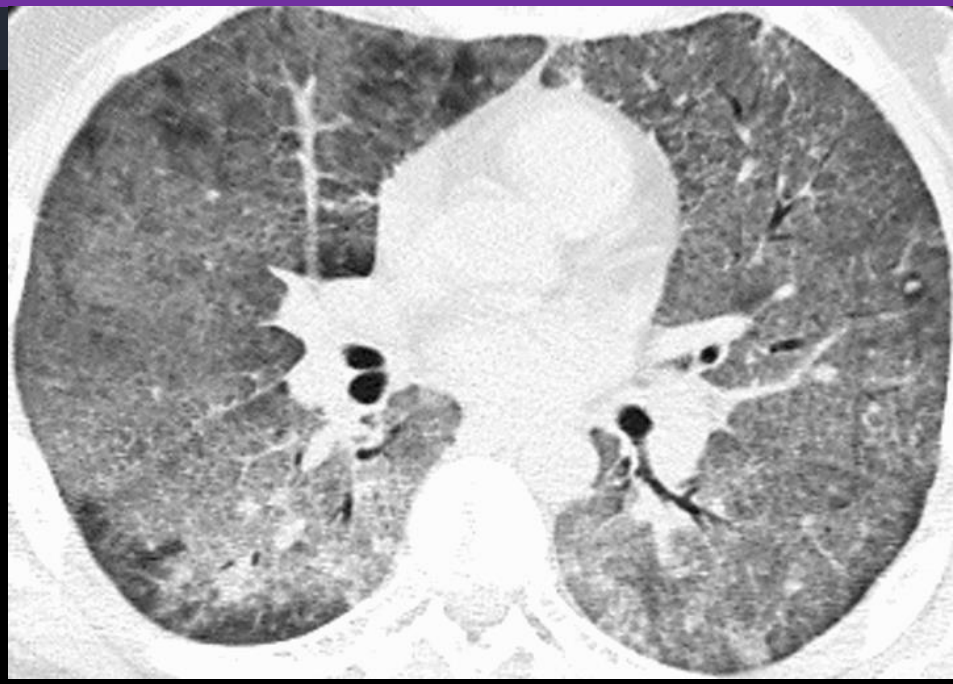
| 項目名稱 | 結果值 | 單位 | 參考範圍 |
|---|---|---|---|
| pH | 7.533 | | (7.35 ~ 7.45) |
| $PaCO_2$ | 33.4 | mmHg | (32 ~ 45) |
| $PaO_2$ | 114.9 | mmHg | (75 ~ 100) |
| $HCO_3$ | 27.5 | mmol/L | (20 ~ 26) |
| BE | 5.2 | mmol/L | (-2 ~ +2) |
| $SaO_2$ | 98.6 | % | |
| $PA\text{-}aO_2$ | 522.2 | mmHg | |

70 y/o female
RA
Methotrexate
6# qwk
Solu-medrol 40mg
q12h

# 33 y/o male, AIDS with PJP

Absolute CD4 count : 4 /ul



Non-Rebreathing Mask 濃度：1.0

pH H 7.494

$pCO_2$ 23 mmHg

$pO_2$ 73 mmHg

P/F:73

High Flow Nasal CPAP

濃度：70/PEEP3

pH 7.474

$PaCO_2$ 28.4 mmHg

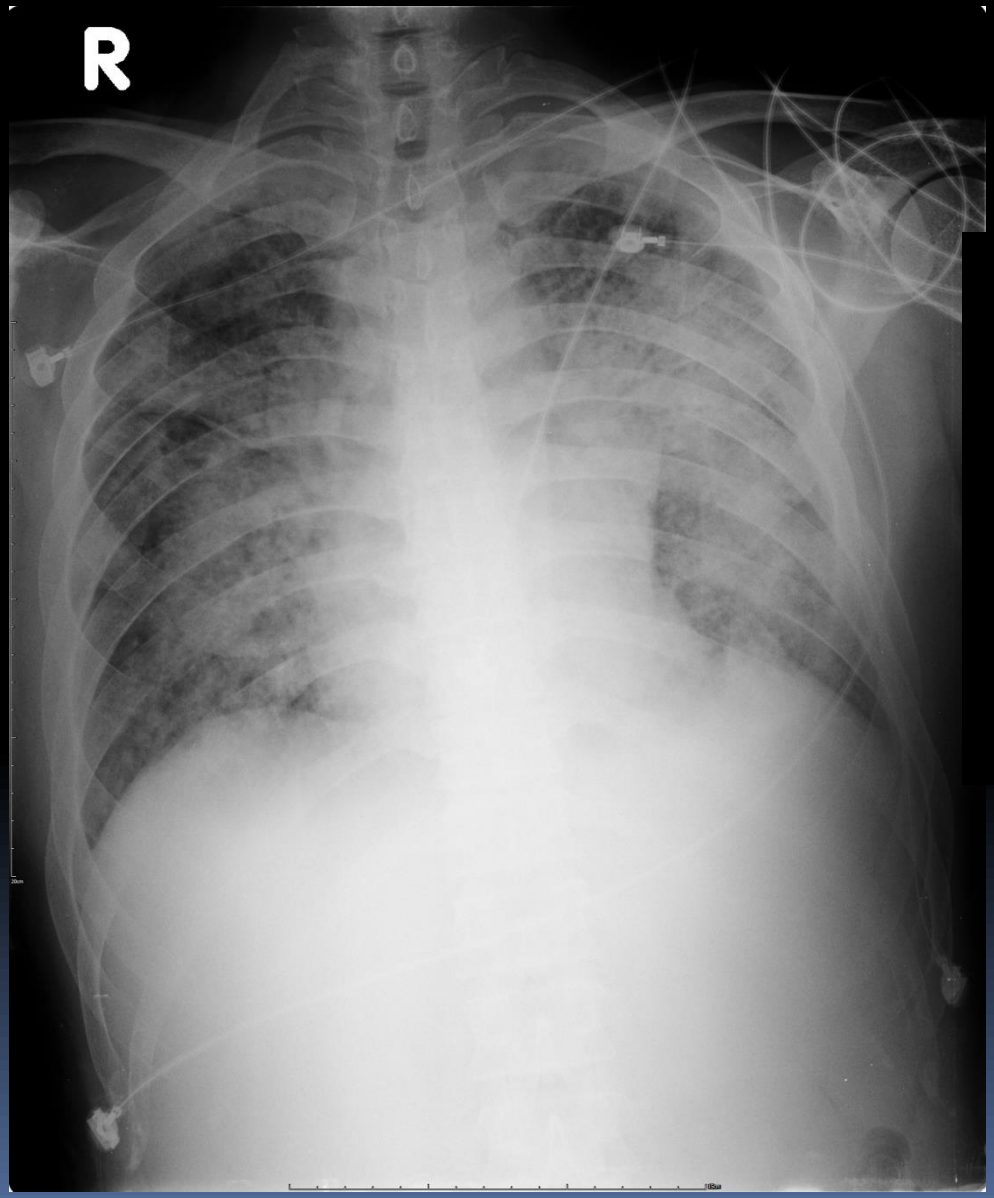
$PaO_2$ 75.4 mmHg

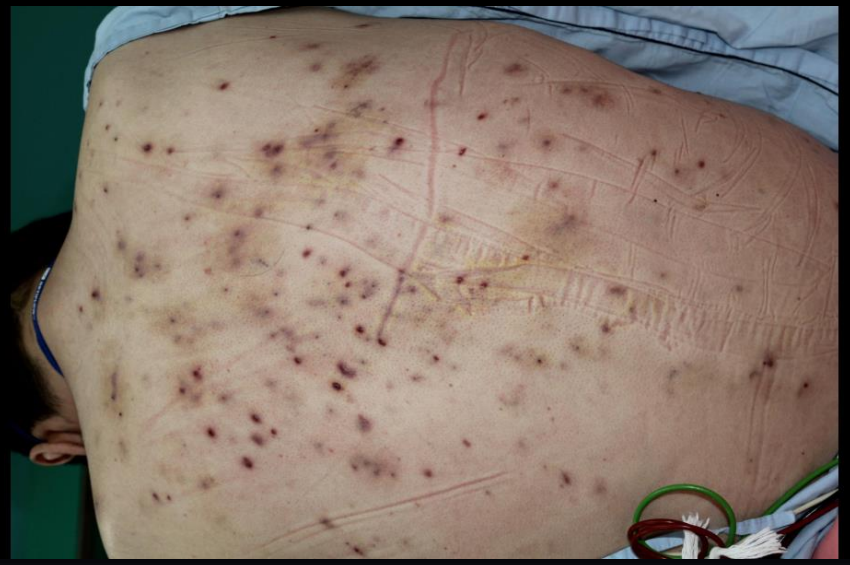
$HCO_3$ 20.4 mmol/L

P/F: 107

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 2014/10/17 21:50 | Ca/瓶 | / | /20 | / | / | / | / | /5 |
| 2014/10/17 08:17 | HFNC | / | /20 | / | 40L/ | / | / | /5 |
| 2014/10/16 20:35 | HFNC | / | /25 | / | 40L/ | / | / | /5 |
| 2014/10/16 08:40 | HFNC | / | /28 | / | 40L/ | / | / | /5 |
| 2014/10/15 21:45 | HFNC | / | /28 | / | 40L/ | / | / | / |
| 2014/10/15 14:25 | HFNC | / | /30 | /1: | 40L/ | / | / | / |
| 2014/10/15 09:30 | HFNC | / | /29 | / | 40L/ | / | / | / |
| 2014/10/15 08:40 | Mask | / | / | /1: | 12L/ | / | / | / |
| 2014/10/15 08:20 | HFNC | / | /28 | / | 40L/ | / | / | / |
| 2014/10/05 21:15 | HFNC | / | /25 | / | 40L/ | / | / | /5 |
| 2014/10/05 08:40 | HFNC | / | /28 | / | 40L/ | / | / | /5 |
| 2014/10/04 21:05 | HFNC | / | /28 | / | 40L/ | / | / | /5 |
| 2014/10/04 08:23 | HFNC | / | /31 | / | 40L/ | / | / | /5 |
| 2014/10/03 20:25 | HFNC | / | /21 | / | 40L/ | / | / | /5 |
| 2014/10/03 08:40 | HFNC | / | /22 | / | 40L/ | / | / | /5 |
| 2014/10/03 08:00 | HFNC | / | /36 | / | 40L/ | / | / | /5 |
| 2014/10/02 20:14 | HFNC | / | /26 | / | 40L/ | / | / | /5 |
| 2014/10/02 07:50 | HFNC | / | /31 | / | 40L/ | / | / | /5 |
| 2014/10/01 20:40 | HFNC | / | /28 | / | 40L/ | / | / | / |
| 2014/10/01 08:20 | HFNC | / | /46 | / | 40L/ | / | / | / |
| 2014/09/30 20:35 | HFNC | / | /35 | / | 35L/ | / | / | / |
| 2014/09/30 16:10 | HFNC | / | /28 | / | 35L/ | / | / | / |

# 1.5 months later: Karposi's



# Maggiore et al. 2014

*American Journal of Respiratory and Critical Care Medicine*

**REDUCES escalation of care**

**IMPROVES comfort & patient compliance**

## STUDY

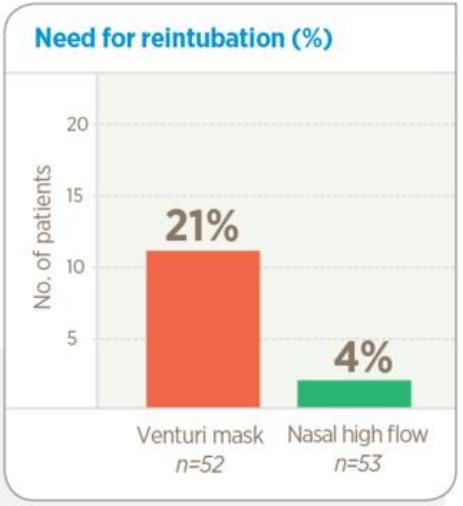
***Maggiore et al.*** **compared the efficacy of nasal high flow (NHF) to use of Venturi mask post-extubation.**

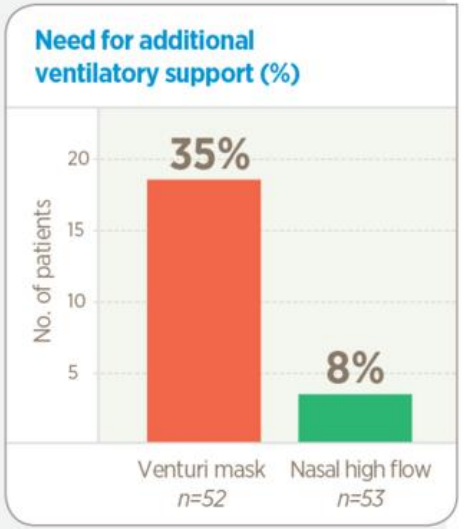
## METHOD

- 105 patients, post-extubation randomized to receive NHF (n = 53) or a Venturi mask (n = 52) (control).
- Primary outcome: $PaO_2/FiO_2$

## RESULTS

- **Significant reduction in the need for reintubation**:
  - 4% (2/53) of NHF patients required reintubation vs. 21% (8/52) in control group.
  - 8% (4/53) of NHF patients required additional ventilatory support vs. 35% (18/52) in control group.
- NHF improved oxygenation for same $FiO_2$ delivered
- Less interface displacement and oxygen desaturation on NHF
- NHF improved comfort and airway dryness




Maggiore et al. *Am J Respir Crit Care Med*. 2014.

Original Investigation | CARING FOR THE CRITICALLY ILL PATIENT

# Effect of Postextubation High-Flow Nasal Cannula vs Conventional Oxygen Therapy on Reintubation in Low-Risk Patients

## A Randomized Clinical Trial

JAMA. 2016 Apr 5;315(13):1354-61

Gonzalo Hernández, MD, PhD; Concepción Vaquero, MD; Paloma González, MD; Carles Subira, MD; Fernando Frutos-Vivar, MD; Gemma Rialp, MD; Cesar Laborda, MD; Laura Colinas, MD; Rafael Cuena, MD; Rafael Fernández, MD, PhD

JAMA | Original Investigation | CARING FOR THE CRITICALLY ILL PATIENT

# Effect of Postextubation High-Flow Nasal Cannula vs Noninvasive Ventilation on Reintubation and Postextubation Respiratory Failure in High-Risk Patients

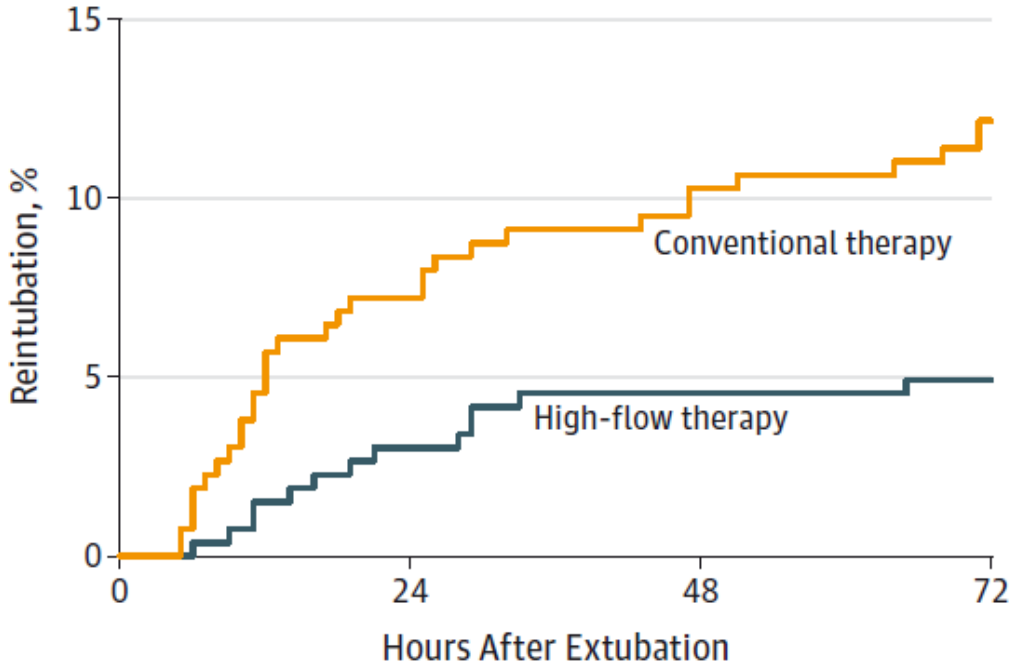
## A Randomized Clinical Trial

JAMA. 2016 Oct 18;316(15):1565-1574

Gonzalo Hernández, MD, PhD; Concepción Vaquero, MD; Laura Colinas, MD; Rafael Cuena, MD; Paloma González, MD; Alfonso Canabal, MD, PhD; Susana Sanchez, MD; Maria Luisa Rodriguez, MD; Ana Villasclaras, MD; Rafael Fernández, MD, PhD

Low risk

## Figure 2. Kaplan-Meier Analysis of Time From Extubation to Reintubation




| No. at risk | | | | |
|---|---|---|---|---|
| Conventional therapy | 263 | 244 | 236 | 231 |
| High-flow therapy | 264 | 256 | 252 | 251 |

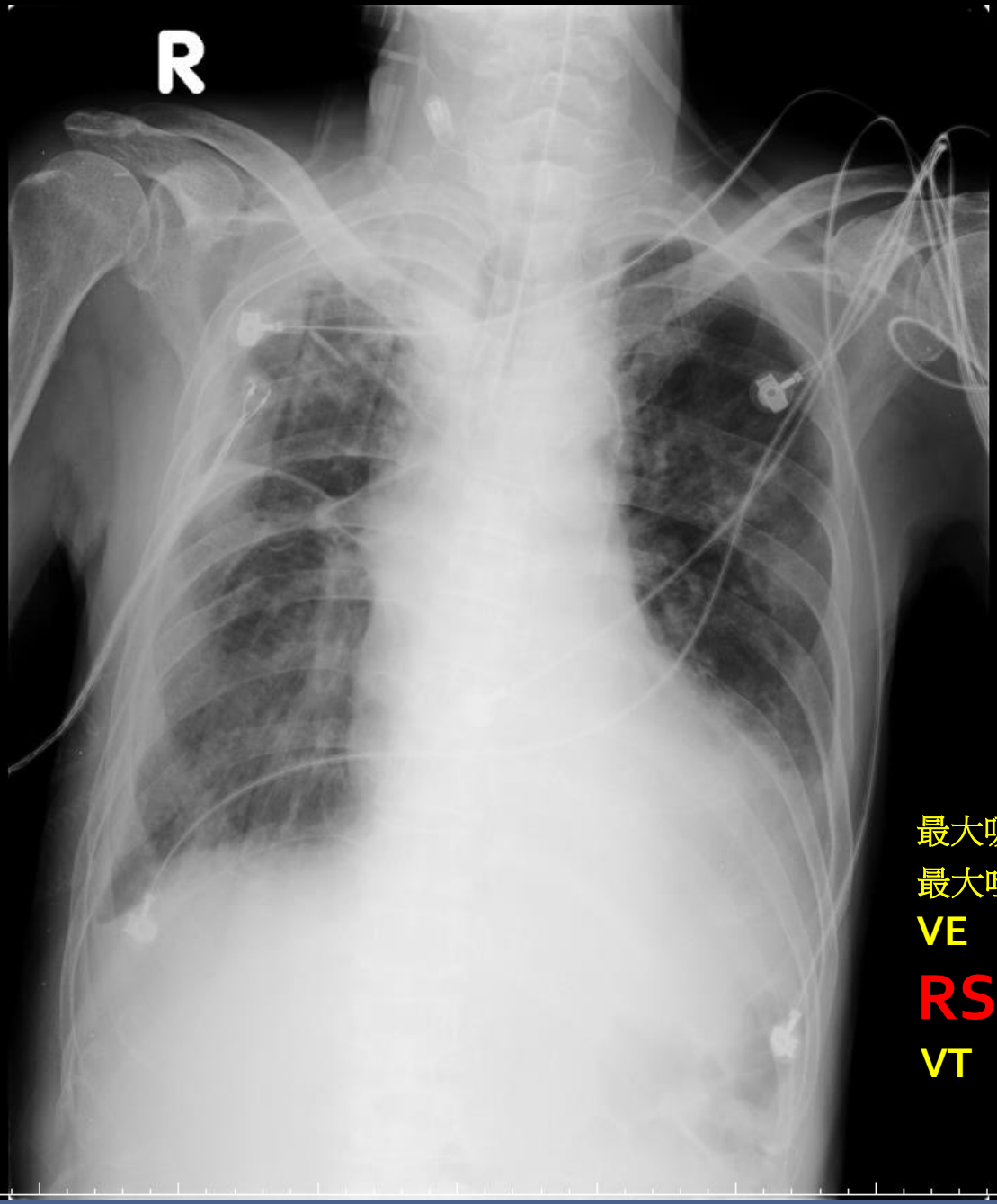
JAMA. 2016 Apr 5;315(13):1354-61

# Low risk

**CONCLUSIONS AND RELEVANCE** Among extubated patients at low risk for reintubation, the use of high-flow nasal cannula oxygen compared with conventional oxygen therapy reduced the risk of reintubation within 72 hours.

# High risk

**CONCLUSIONS AND RELEVANCE** Among high-risk adults who have undergone extubation, high-flow conditioned oxygen therapy was not inferior to NIV for preventing reintubation and postextubation respiratory failure. High-flow conditioned oxygen therapy may offer advantages for these patients.

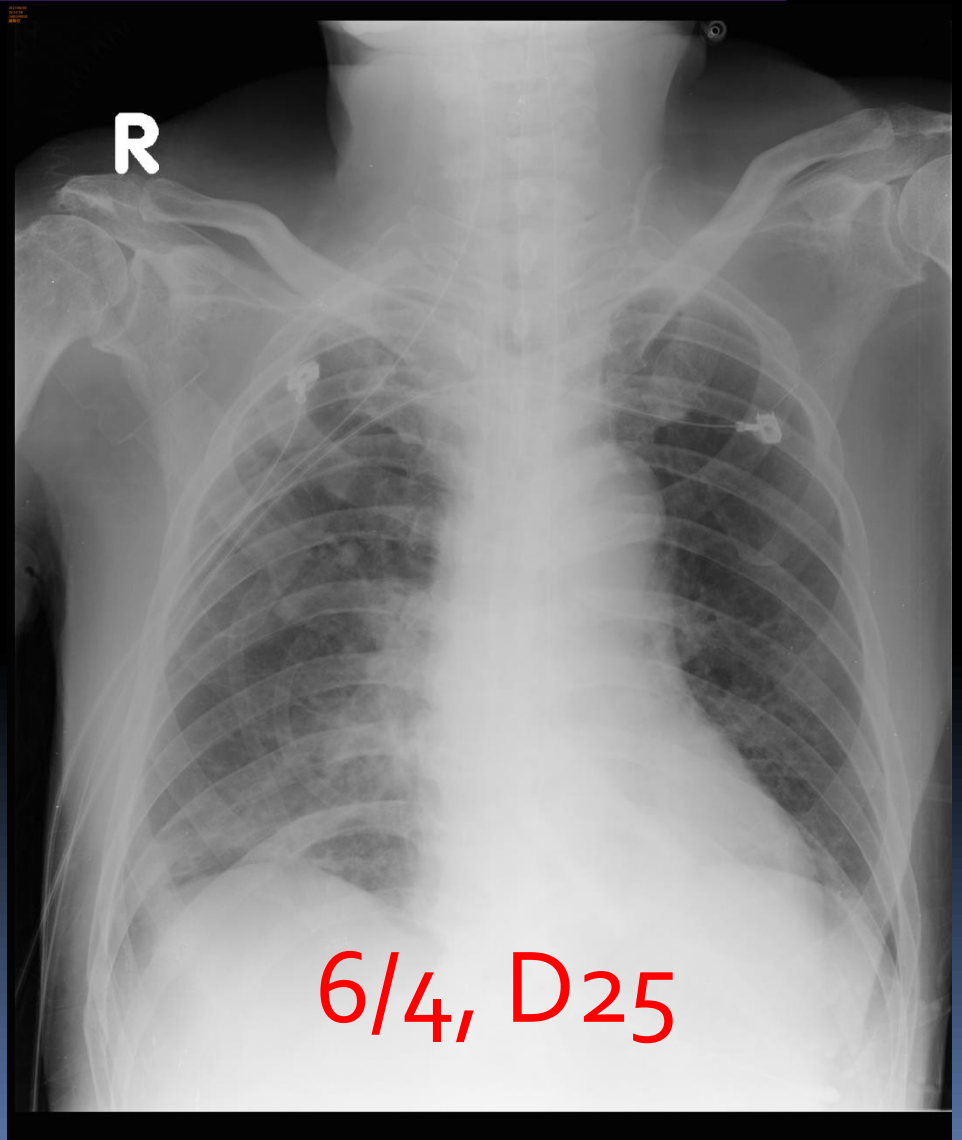

R
MMH Taipei
07:07:31
9Y
014/07/25
: 1001
n: 1001
呂XX
79 y/o male
COPD/asthma
(ACOS?)
Heavy smoker
最大吸氣壓 -28 cmH2O
最大吐氣壓 +34 cmH2O
VE 7.65 L/min
RSI 169
VT 212.5 ml
TP-AP Chest 1 view
WC:2048 ,WW:4096

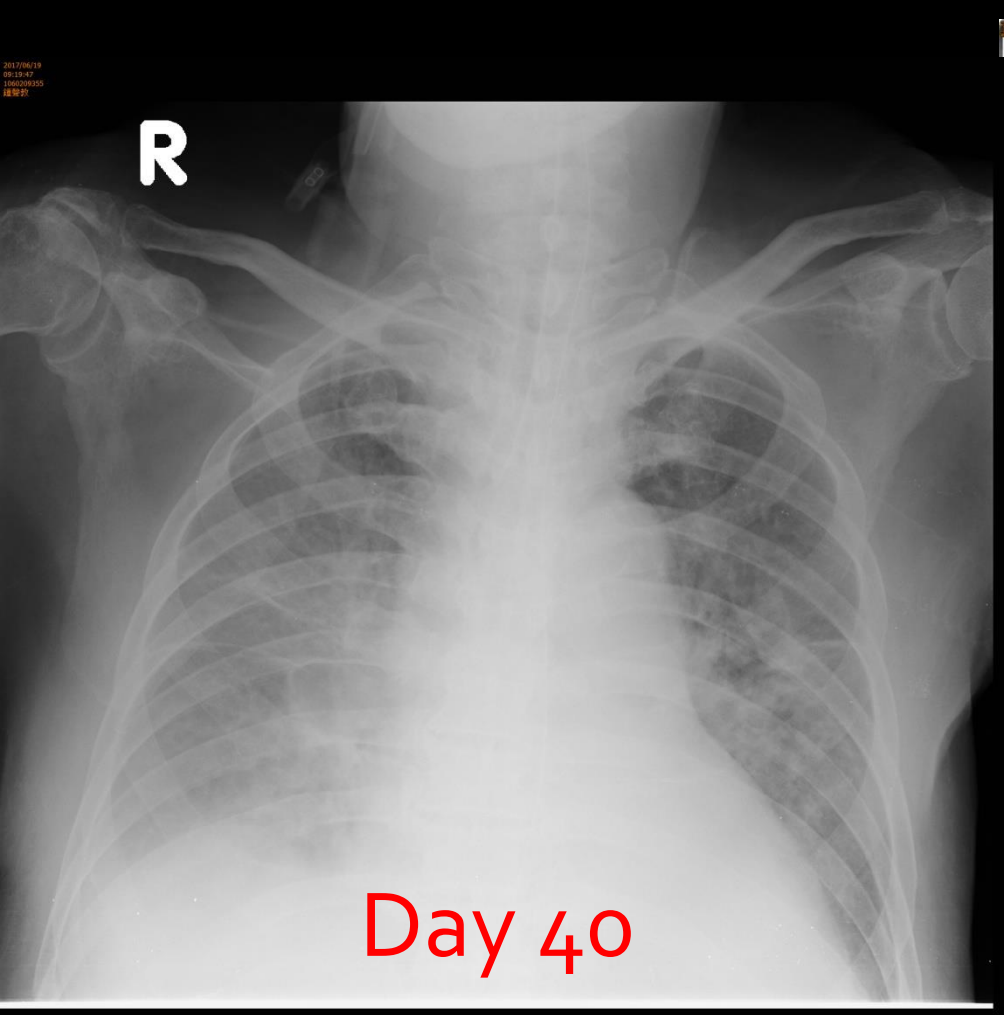
# 82 y/o male

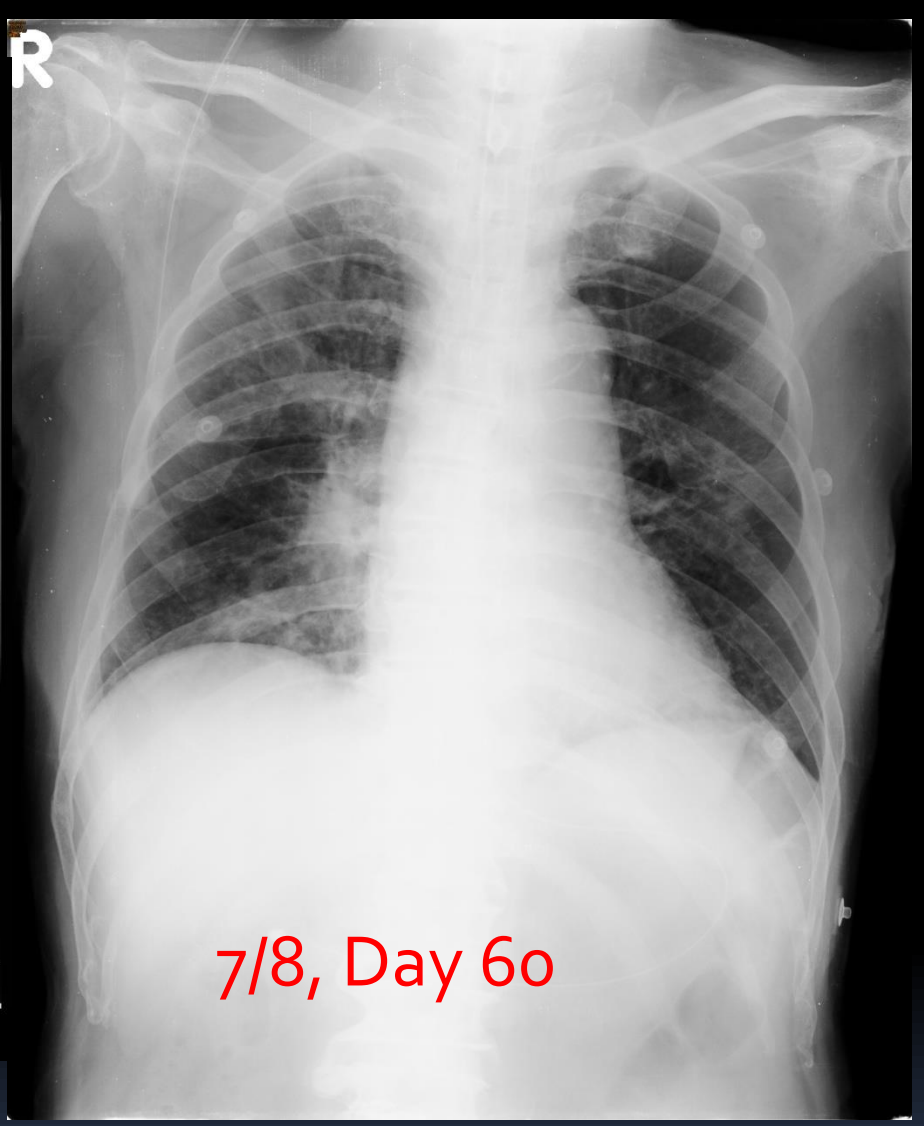
- 5/10 ( 插管第一天, Day 1) admitted to XX醫院XX分院 due to acute respiratory failure and ETT + MV
- AAD and sent to XX醫院 for Hemodialysis.
- After H/D, still MV dependent.
- RCC transferring was suggested.
- AAD to MMH on **6/4( day 25).**

# 82 y/o male

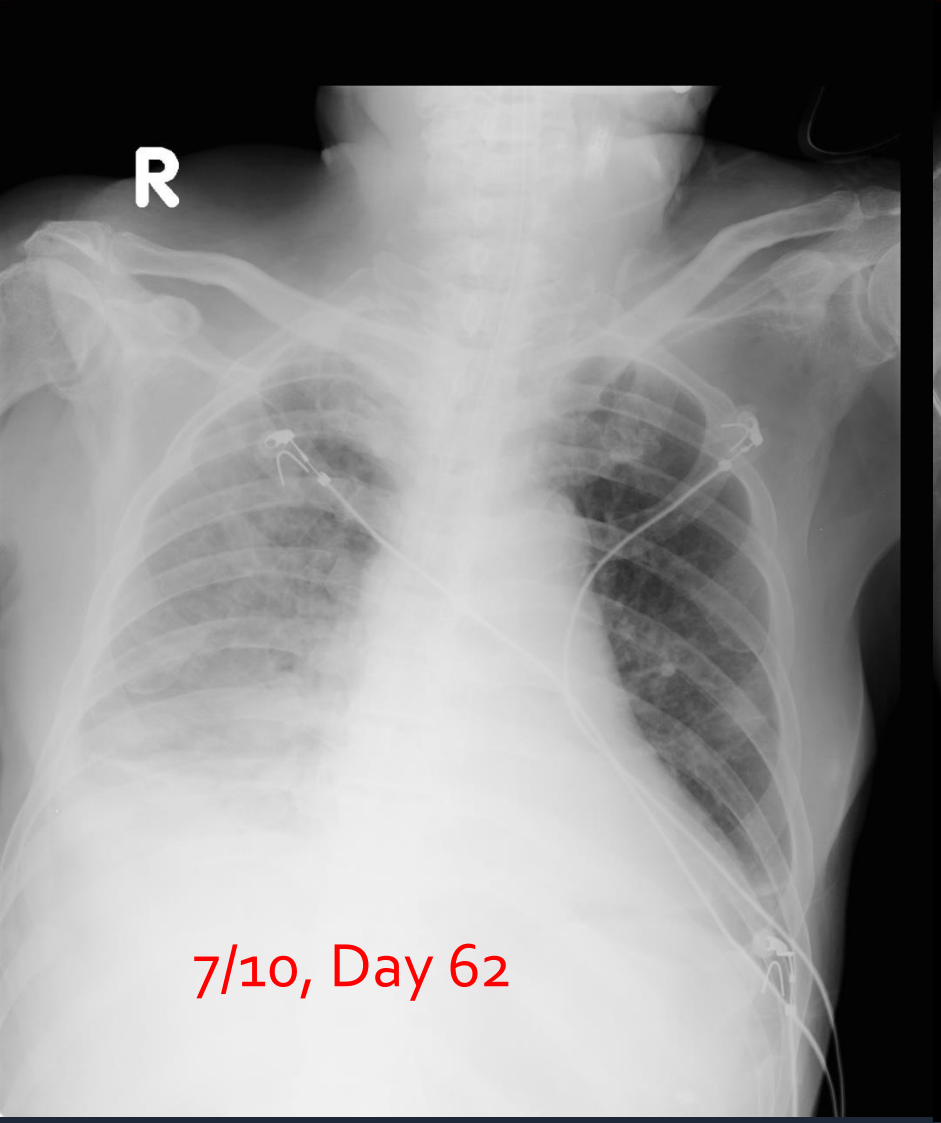
- CKD, Stage 4-5
- Diabetes mellitus,type 2
- Essential hypertension
- Old CVA
- Congestive heart failure NYHA Fc II.
- Valvular heart disease (moderate to severe TR)



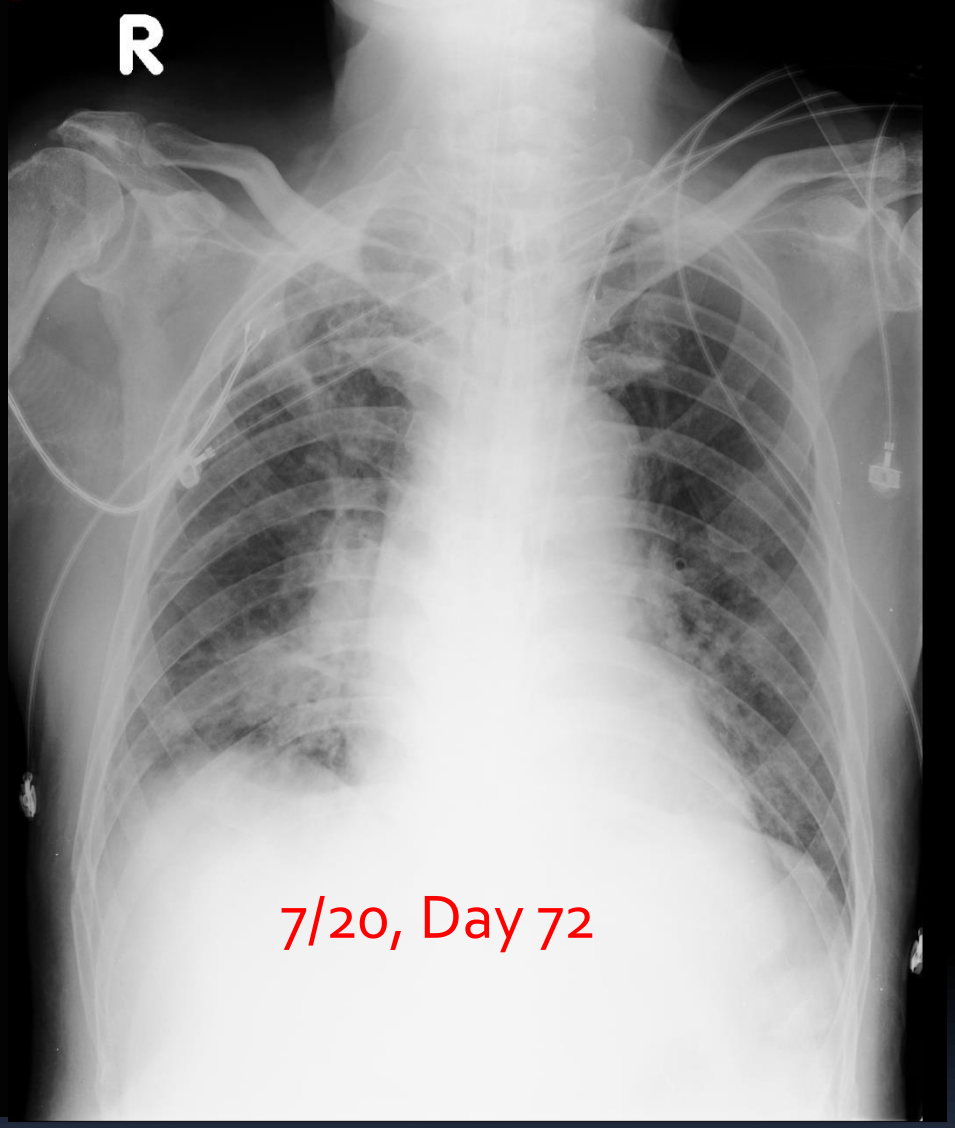



家屬拒氣切, 7/8( day 60) transfer to nursing home




7/10, Day 62

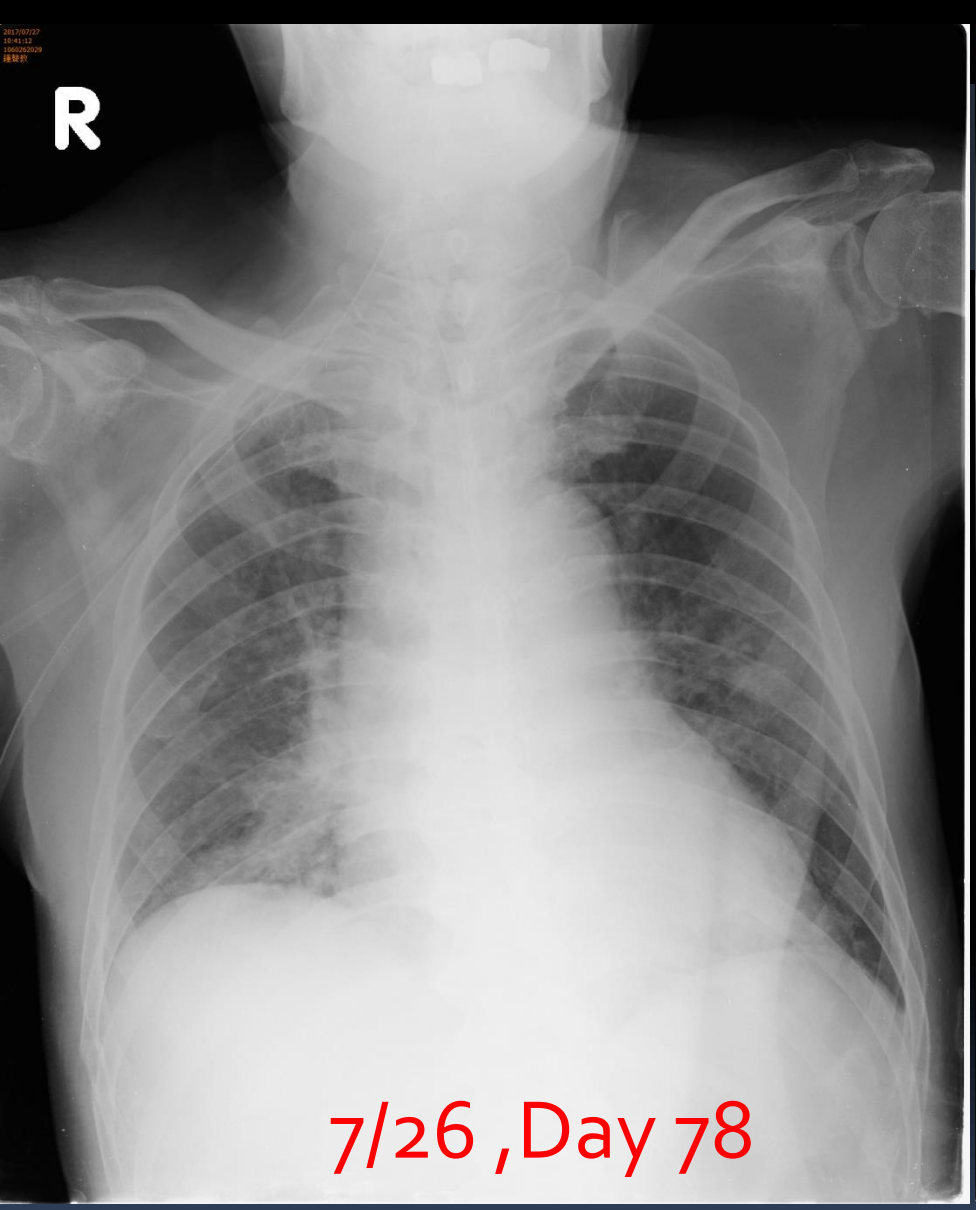


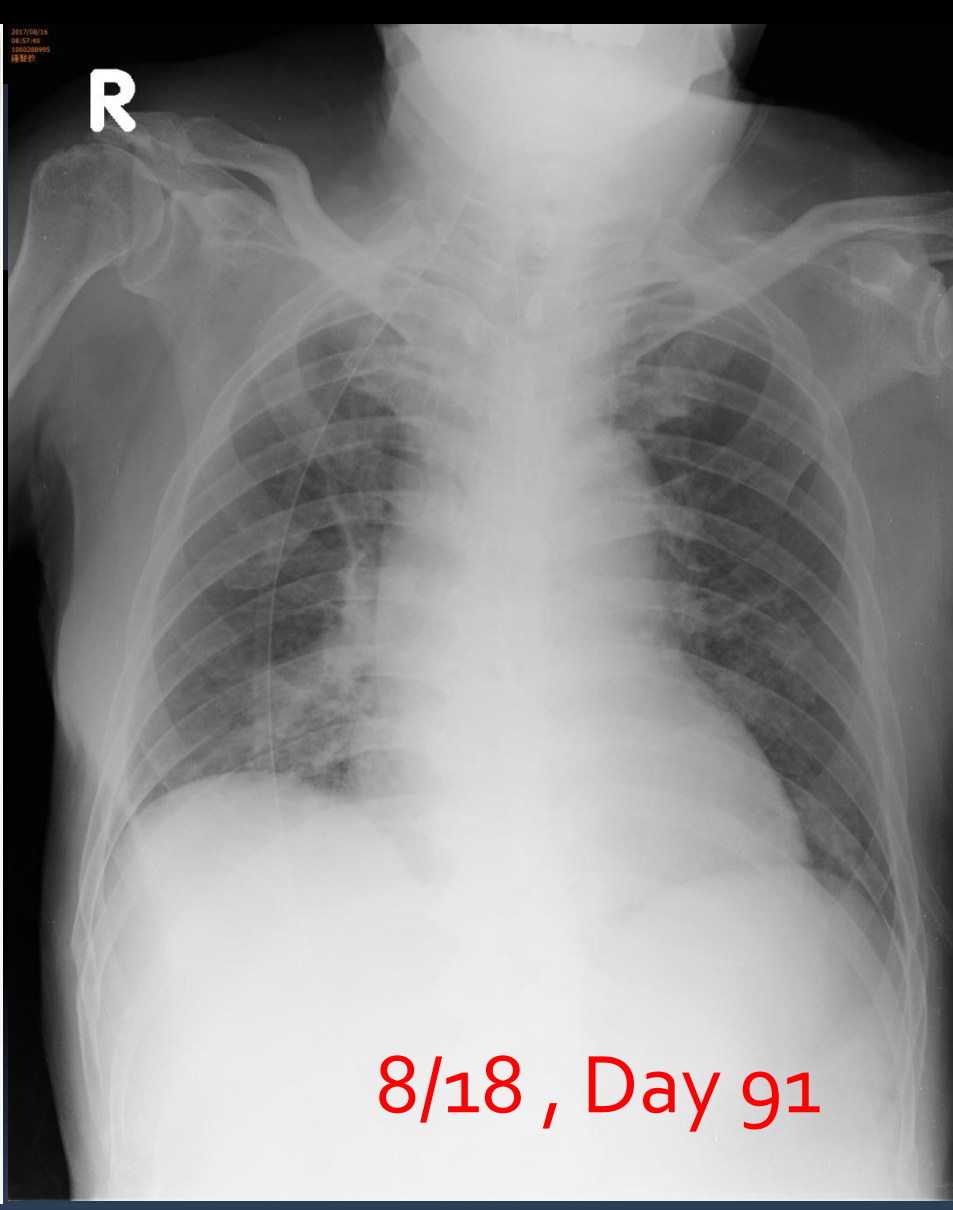

7/20, Day 72

Readmission to MICU
Respiratory failure, on MV

| | | |
|---|---|---|
| 最大吸氣壓 | -20 | cmH2O |
| 最大吐氣壓 | 15 | cmH2O |
| VE | 6.45 | L/min |
| RSI | 121 | |
| VT | 230 | ml |

Try HFNC




Transfer to ward

Discharge, room air

# Effect of Postextubation High-Flow Nasal Cannula vs Conventional Oxygen Therapy on Reintubation in high-risk patients

Mackay Memorial Hospital
Taipei, Taiwan

# Study Framework

- MMH, Medical ICU
- Respiratory failure requiring invasive MV use > 48 hours. Then passed spontaneous breathing trial and prepared for extubation
- "**High-risk** for **reintubation**", at least one of below :
  - Age > 65 y/o, CHF, COPD, ESRD, bronchiectasis or old TB destroyed lung, MV > 21 days, inadequate secretions management ability, BMI>30, ARDS,...)
- Randomized immediately postextubation (2 groups):
  - HFNC vs.
  - Conventional oxygen therapy : high flow aerosol mask, nasal cannula

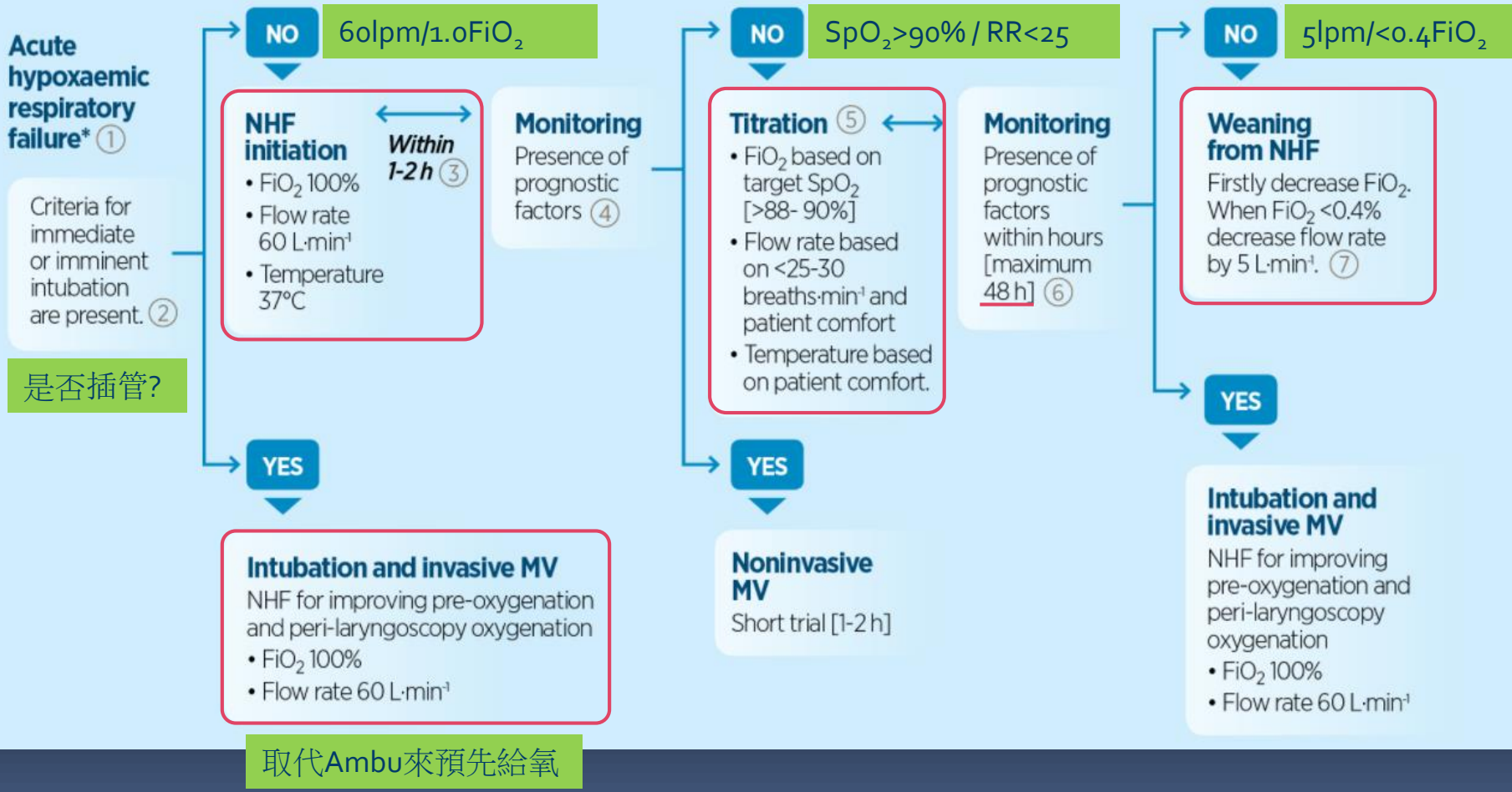
# Table 2. Primary Outcome

| Variables | Oxygen Therapy, No. (%) | | | |
|---|---|---|---|---|
| | Conventional (n=27 ) | High-Flow Nasal cannula (n=29 ) | Total (**n=56**) | P value |
| **Primary outcome** | | | | |
| **Extubation success, no. (%)** (no reintubation or NIV use within 72 hours postextubation ) | 20 (74%) | 29 (100 %) | 49 (87.5 %) | **0.0038** |

- OR (HFNC vs conventional) = ***21.5854*** *( P=0.0038*, MH method )
- **HFNC** vs. **conventional oxygen therapy** (in **high-risk** reintubation patients)
- **Better** weaning successful rate, within 3 days postextubation, in HFNC group *( P<0.0.5 )*

# Ischaki et al. 2017

*Ischaki. Eur Respir Rev. 2017.*



# Take home message for NIV

- The right patient
- The right time
- The right equipment
- The right environment
- Ongoing audits and quality assurance should be done

Lancet Respir Med 2018; 6: 935–47

# For HFNC

- Enhanced comfort
- Avoidance of desiccation and epithelial injury
- Facilitated secretion removal
- Reduced inspiratory entrainment of room air
- Washout of upper airway dead space
- Counterbalance auto-PEEP
- Decreased work of breathing
- **Hypoxic respiratory failure**
- **Postextubation**
- **Immunocompromised patient**

- Thanks for your attention