PLACE

PLATFORM OF LABORATORIES FOR ADVANCES IN CARDIAC EXPERIENCE

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di Confindustria
Auditorium
della Tecnica

9ª Edizione

30 Settembre
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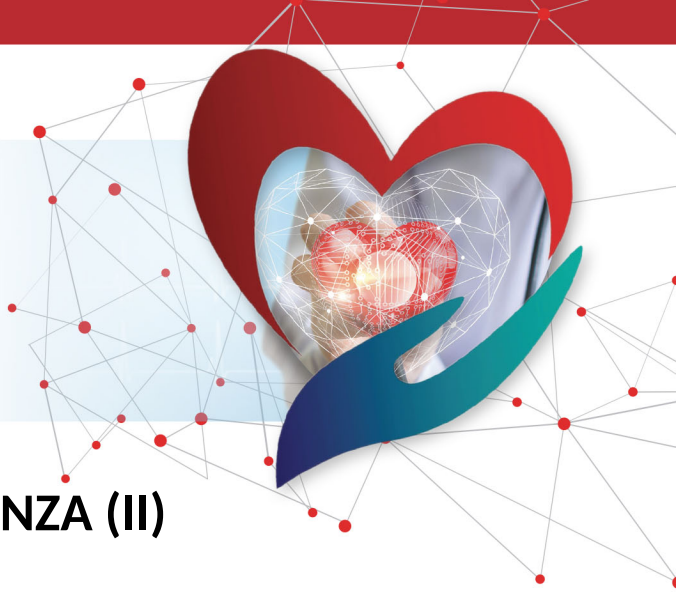

TEN MINUTES ANSWERS IN CARDIOLOGIA D'URGENZA (II)

Insufficienza cardio-respiratoria acuta in PS: utilità di una NIV precoce e modalità di ventilazione

Dott. Enrico Mirante
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Ospedale Sant'Eugenio Roma

INSUFFICIENZA RESPIRATORIA ACUTA

Arterial Hypoxemia

↓

End-organ Hypoxia

↓

Anoxic brain injury

↓

Cardiac Arrest

↓

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ESC European Society of Cardiology
European Heart Journal (2018) 39, 17–25

Indications and practical approach to non-invasive ventilation in acute heart failure

Nearly 90% of AHF patients complain of dyspnoea but fewer than half present respiratory failure affecting blood gas analysis, in form of hypoxaemia, hypercapnia or acidosis

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Indications and practical approach to non-invasive ventilation in acute heart failure

AHF *AND*....

- ✓ COPD
- ✓ ASTHMA
- ✓ LARGE PLEURAL EFFUSION
- ✓ ATELECTASIS
- ✓ PULMONARY EMBOLISM

may precipitate or aggravate respiratory failure

Insufficienza cardio-respiratoria acuta in PS

Insufficienza Cardiaca Acuta (AHF)

Edema Polmonare Acuto Cardiogeno
Shock Cardiogeno

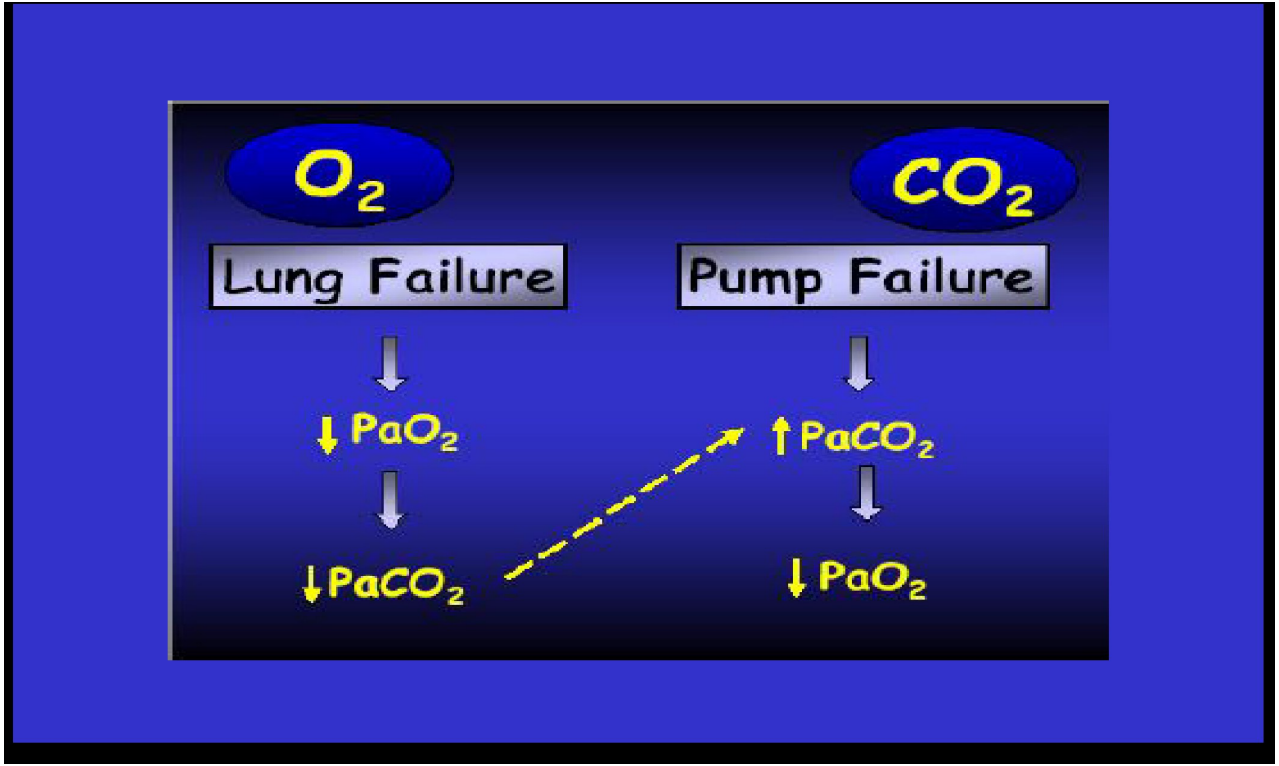
ACUTE HYPOXEMIC RESPIRATORY FAILURE

- INCREASED BREATHING FREQUENCY
- LOW OXYGEN SATURATION OR PaO_2/FiO_2 while receiving supplemental oxygen

Fatica dei muscoli respiratori

- **Condizione caratterizzata dall'incapacità di un muscolo di sviluppare forza o velocità contrattile in seguito ad un aumentato carico di lavoro, reversibile dopo il riposo**

- **Il volume corrente dei gas (volume minuto) non è più in grado di soddisfare le richieste dell'organismo**


O_2
CO_2
Lung Failure
Pump Failure
↓ PaO_2
↓ $PaCO_2$
↑ $PaCO_2$
↓ PaO_2

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Acute Cardiogenic pulmonary oedema

Pulmonary Oedema is the second most frequent (after pneumonia) acute parenchymal alteration causing Respiratory Failure

- ✓ *Rapid increase in pulmonary hydrostatic pressure and trans-vascular fluid filtration*
- ✓ *Excess of interstitial and alveolar fluid ☾ significant reduction of gas exchange and a concomitamt shunt effect*

Cardiorespratory collapse in hours or minutes unless therapeutic action is taken

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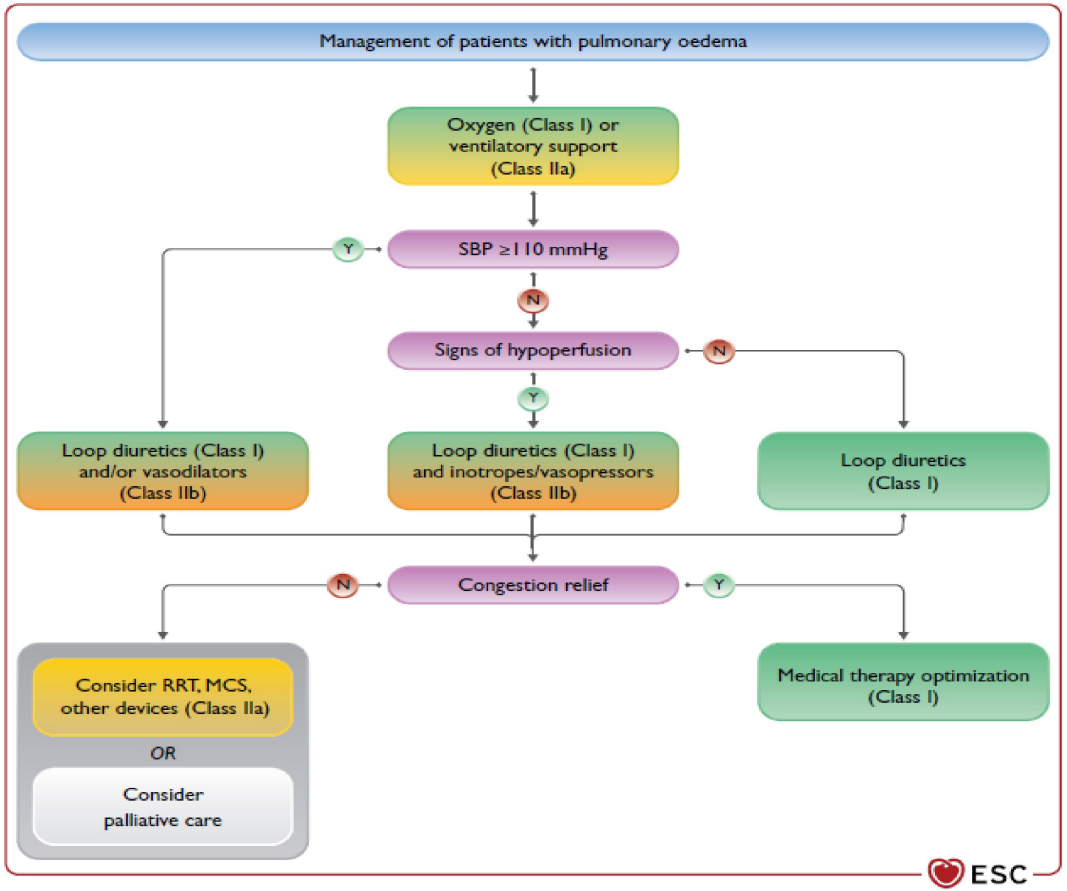
Table 1 Diagnostic criteria for acute cardiogenic pulmonary oedema

Clinical criteria (all of them)
• Acute respiratory distress[1]
• Physical examination[2]
• Orthopnoea
• Respiratory failure[3]
Diagnostic confirmation (at least two of the following)
• Clear signs of pulmonary congestion on chest radiography or CT scan
• Multiple B-lines on lung ultrasound[4]
• Elevated pulmonary capillary pressure on catheterization
• Increased total lung water on pulse contour and thermodilution analysis system
• Signs of elevated filling pressures on echocardiography[5]
• Significant elevation of natriuretic peptides[6]
(1) Respiratory distress: Acute increase in the work of breathing (assessed by single inspection), significant tachypnea (RR > 25breaths/min)[a], may be with the use of accessory muscles or abdominal paradox
(2) Crackles ± wheezes over the lungs, third heart sound[b]
(3) Oxygen saturation on room air by pulse-oximetry (SpO_2) <90%. Arterial blood gases may also show PaO_2 < 60 mmHg, $PaCO_2$ > 45 mmHg or PaO_2/FiO_2 < 300 mmHg
(4)≥3 B-Lines in two chest zones on each hemithorax[7,8]
(5) E/E′ > 15. Other parameters of elevated left atrial pressure may also be considered
(6) Natriuretic peptides[c] BNP > 400 or N-ProBNP > 900 (or 1800 in > 75 years)

[a]Respiratory rate may be lower and orthopnoea may be absent in obtunded patients.
[b]Patients with low systolic blood pressure (i.e. <90 mmHg) may be considered to have cardiogenic shock rather than ACPE.
[c]In 'flash pulmonary oedema' BNP may be lower.
RR, respiratory rate; CT, computer tomography.

European Heart Journal (2021) 42, 3599—3726



European Heart Journal (2021) 42, 3599–3726

2021 ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure

- *Non invasive positive pressure ventilation, either continuous positive airway pressure and pressure support, improves oxygenation and ph and decreases pCO_2 and work of breathing.*
- *Meta-analyses suggest it may improve dyspnoea and reduce the need for intubation and mortality, compared with traditional oxygen therapy*
- *Non-invasive positive pressure ventilation should be started as soon as possible in patients with respiratory distress (respiratory rate > 25 breaths/min, spO_2 < 90%) to improve gas exchange and reduce the rate of endotracheal intubation.*
- *The fraction of inspired oxygen (FiO2) should be increased up to 100%, if necessary, according to oxygen saturation level*

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Cardiogenic shock

- When Cardiogenic Shock is secondary to *LV failure*, acute *respiratory failure* is nearly *always present*, with concomitant *pulmonary oedema* and *tissue hypoperfusion*.
- The reduction in Lung Perfusion produces an *increas in pulmonary dead space* (some ventilated areas receive less blood) *increasing the ventilation perfusion mismatch*

Reconsidering Vasopressors for Cardiogenic Shock

Everything Should Be Made as Simple as Possible, but Not Simpler

Pierre Squara, MD; Steven Hollenberg, MD; and Didier Payen, MD, PhD

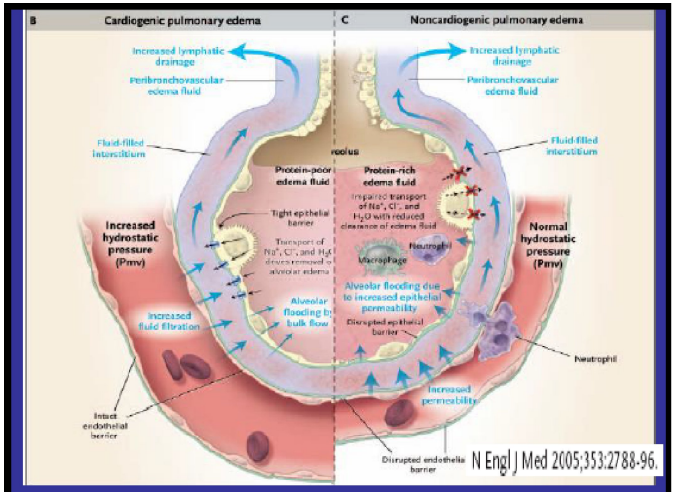
CHEST 2019; 156(2):392–401

After time, in any shock state the symptoms can be dominated in different proportion by the systemic inflammatory response

Compensatory mechanisms may be less efficient
alterations in myocardial contraction , lung function, microcirculation and organ function

The response to vasoactive mediators and drugs can be severely altered

ARDS



Chiumello and Brioni *Critical Care* (2016) 20:132
DOI 10.1186/s13054-016-1304-7

Lung Edema

Increased Pleural Pressure

Increased Hydrostatic Pressure

Reduced Lung Gas Volume

Nonaerated Regions

Consolidated or Atelectatic
Mainly in the more dependent lung regions

European Heart Journal (2021) **42**, 3599—3726

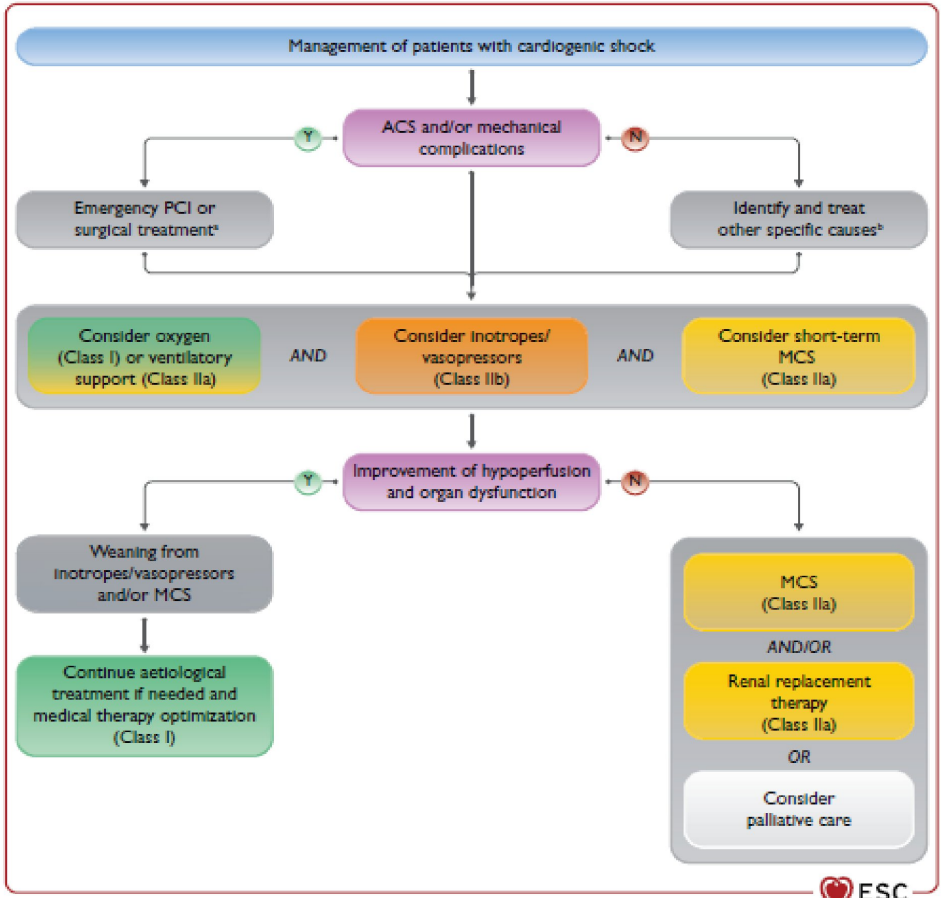


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Table 2 Main physiologic effects of positive intrathoracic pressure

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

[a]In patients with AHF with elevated LV preload and afterload, cardiac output may increase as consequence of the application of positive intrathoracic pressure.
RV, right ventricle; LV, left ventricle.

In AHF patients with elevated preload and afterload PIP may increase cardiac output by reducing both pre- and after load

Isolated RV dysfunction: PIP may be detrimental increase in RV afterload precipitates or aggravatEs RV failure

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Cardiogenic Shock

Although the use of NIV remains limited in hypotensive patients, it may be cautiously considered in selected CS patients without severe haemodynamic instability

The potential use of HFNC in this context should be assessed

Noninvasive Ventilation and Oxygenation Strategies

Patrycja Popowicz, MD, MS[a,*], Kenji Leonard, MD[b,1]

Surg Clin N Am 102 (2022) 149–157

High Flow Nasal Cannulas

- Blend 100% O2 and room air to produce gas with the desired FiO2
- High enough flow up to 60 L/min providing heated humidified air
- Delivery of air volumes greater than physiological tidal volume creating greater oxygen diffusion gradient
- Wash out of physiological dead space
- Increased tidal volume
- Increased end expiratory volume
- Approximate 1 mmHg of PEEP for every 10L/min of flow

ACUTE HYPOXEMIC RESPIRATORY FAILURE

2017 American Thoracic Society AND European Respiratory Society

LINEE GUIDA

Table 1. Current Guidelines for Adult Noninvasive Ventilation

Patient Category	Recommendation	Certainty of Evidence
Hypercapnic COPD exacerbation	Do it*	High
Cardiogenic pulmonary edema	Do it*	Moderate
Postoperative patients	Do it	Moderate
Palliative care	Do it	Moderate
Immunocompromised	Do it	Moderate
Postextubation in patients at high risk	Do it	Low
Trauma	Do it	Moderate
Weaning patients who are hypercapnic	Do it	Moderate
Prevention of hypercapnia COPD exacerbation	Do not do it	Low
Postextubation respiratory failure	Do not do it	Low
Acute asthma exacerbation	No recommendation	
De novo respiratory failure	No recommendation	
Pandemic viral illness	No recommendation	

* Indicates a strong recommendation, all other recommendations (for or against) are conditional; further evidence may impact the certainty of effect for conditional recommendations (From Reference 13).

RESPIRATORY CARE • JUNE 2019 VOL 64 NO 6

ACUTE HYPOXEMIC RESPIRATORY FAILURE

NIV: BENEFICIO CERTO

- ✓ *Edema Polmonare Acuto Cardiogeno (CPAP O NIV ☾ riduzione mortalità ed IOT)*
- ✓ *Pazienti post-operati (resezione polmonare, chirurgia addominale)*
- ✓ *Trauma toracico (CPAP O NIV ☾ riduzione mortalità, IOT, degenza in T.I. e polmonite nosocomiale)*

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American Journal of Respiratory and Critical Care Medicine Volume 199 Number 11 | June 1 2019

ACUTE HYPOXEMIC RESPIRATORY FAILURE

2017 American Thoracic Society AND European Respiratory Society

LINEE GUIDA

L'USO DELLA NIV NON E' RACCOMANADATO NELL'INSUFFICIENZA RESPIRATORIA IPOSSICA ACUTA DI NUOVA INSORGENZA.

INSUFFICIENZA RESPIRATORIA IPOSSICA ACUTA DI NUOVA INSORGENZA

(De Novo Hypoxemic Respiratory Failure):

Insufficienza respiratoria ipossica in assenza di sottostante patologia cronica dell'apparato respiratorio o di scompenso cardiaco (sepsi, polmonite, atelettasia)

TASSO DI INTUBAZIONE DOPO TRATTAMENTO CON NIV 50 – 66%

CPAP Continuous Positive Airway Pressure

- **La pressione applicata durante la fase inspiratoria è uguale alla pressione di fine espirazione.**
- **Inizio e fine dell'inspirazione sono determinate dal paziente**
- **Flusso e Volume sono completamente generati dai muscoli del paziente**

Il suo uso è appropriato quando i muscoli respiratori del paziente sono in grado di generare una forza muscolare sufficiente

Effetti della CPAP

Miglioramento dell'ossigenazione (PaO_2)

- ***Riduzione della probabilità del collasso delle piccole vie aeree***
- ***Riapertura delle aree atelettasiche del polmone (reclutamento alveolare)***
- ***Aumento della CFR e quindi della compliance***

"However CPAP is not indicated in the presence of symptomatic CO2 retention"

Non-invasive ventilation in cardiogenic pulmonary edema

Giuseppe Bello, Paolo De Santis, Massimo Antonelli

Ann Transl Med 2018;6(18):355

NON INVASIVE VENTILATION (NIV)

- Mechanical respiratory support using techniques that do not bypass the upper airway
- Is generally delivered using a combination of pressure support ventilation (PSV) plus positive end-expiratory pressure (PEEP)
- Unlike NIV, CPAP does not deliver ventilation per se beacuse it does not assist inspiration

OBIETTIVI DELLA NIV

- *Ridurre il lavoro respiratorio*
- *Migliorare gli scambi gassosi*
- *Ridurre Intubazione Oro - Tracheale*

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CPAP OR NIPPV

«Either tecnique can be used as first line in ACPE but it seems reasonable to prefer NIPPV in patients with severe hypercapnia, although little evidence supports this recommendation»

16.	Patients receiving NIV are to be positioned to achieve maximal chest wall movement and prevent upper airway obstruction [3].	Consensus

Position of patient

The patient should be in a sitting or semi-recumbent position in bed. Consider side lying position to remove pressure from a pendulous abdomen (obesity / pregnancy).

30.	Patients are to be encouraged to sit out of bed as tolerated. When in bed they are to be positioned in an upright position to facilitate chest wall expansion.	Pressure Injury Prevention Guideline

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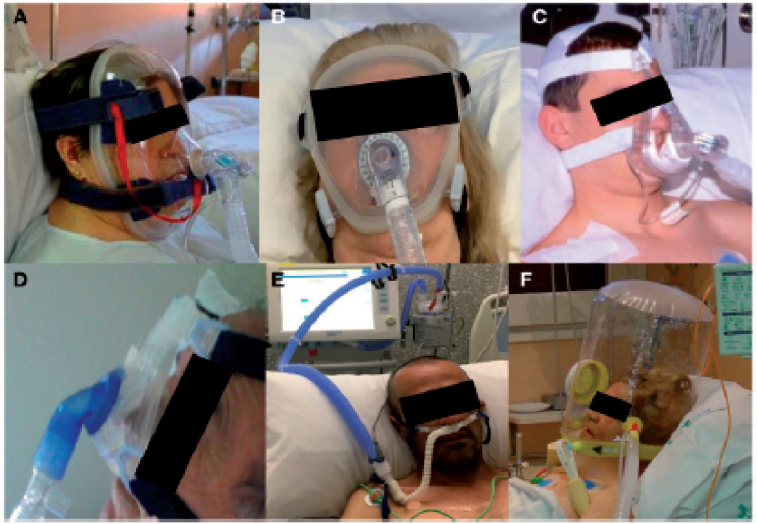

Figure 3 Main interfaces used in non-invasive ventilation (NIV). (*A–B*) Two different models of *total-face mask* (probably with the best patient-ventilator adaptation)[69]; (*C*) *Oronasal mask*: the most used interface; (*D*) *Nasal mask*: not indicated in patients breathing by the mouth as those with acute pulmonary oedema. (*E*) *High-flow nasal cannula*: (see text); (*F*) *Helmet*: mostly used for continuous positive airway pressure mode, it allows more patient autonomy (speaking and eating), convenient when anticipating prolonged NIV. Other interfaces like *nasal pillows, mouthpieces or laryngeal masks are usually* not considered in acute heart failure.

BTS guidelines

Davidson AC, *et al. Thorax* 2016;**71**:ii1–ii35. doi:10.1136/thoraxjnl-2015-208209

Choice of interface for NIV

Recommendation

2. A full face mask (FFM) should usually be the first type of interface used (Grade D).

Good practice points

- A range of masks and sizes is required and staff involved in delivering NIV need training in and experience of using them.
- NIV circuits must allow adequate clearance of exhaled air through an exhalation valve or an integral exhalation port on the mask.

Non-invasive Ventilation Guidelines for Adult Patients with Acute Respiratory Failure 2014

The helmet is a special interface device designed to contain the head of the patient completely and it provides a seal all around the patient's neck. The helmet may have several advantages compared to other interfaces. It allows relatively free movement of the head while maintaining a good seal without compression on the face or head. The lack of pressure points on the face avoids the main complications associated with the use of a face mask: intolerance, pain and skin necrosis [42]. However, concerns in relation to use of helmets with hypercapnic patients include less efficient correction of $PaCO_2$ [43] and increased patient ventilator asynchrony compared with face masks [44].

When using helmet, high gas flow (40 – 60 L/min) is required to mantain a low inspired partial pressure of CO_2

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Table 4 Contraindications of NIV

Absolute	Cardiac or respiratory arrest
	Anatomical abnormality (unable to fit the interface)
	Inability to keep patent airway (uncontrolled agitation, coma[a] or obtunded mental status)
	Refractory hypotension
Relative	Mild agitation or poor cooperation
	Mild hypotension
	Upper gastrointestinal haemorrhage or vomiting
	Inability to expectorate copious secretions
	Recent frail upper gastrointestinal or airway surgery
	Multiorgan failure
	Isolated right ventricular failure

[a]Modalities like NIV with volume controlled or 'Average volume assured pressure support' have been used in hypercapnic encephalopathy.

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Table 5 Monitoring NIV

Patient
Respiratory rate
Other vital signs
Dyspnoea/accessory muscle use/abdominal paradoxical breathing
Level of consciousness
Comfort with the interface
Collaboration
Ventilator parameters
Tidal volume (>4 mL/Kg; 6–7 mL/Kg) and minute ventilation
Air leakage volume (<0, 4 L/s or <25 L/min)
Pressure support and PEEP settings
Asynchrony (ineffective efforts, auto-triggering, double-triggering, short/long cycle)[a]
Trigger/slope (ramp)/inspiration time/expiration settings
Auto-PEEP
Alarms (apnoea or high respiratory rate, low/high minute ventilation, others)
Gas exchange
Continuous pulse-oximetry (SpO_2)
Arterial or venous blood gas samples[b]

Risk factors of failure

- Before initiation
  - Lung infection
  - Altered mental status
  - Hypotension
  - High severity scores
  - Copious secretions
  - Extremely high respiratory rate
  - Severe hypoxaemia in spite of high FiO_2
- After initiation
  - Inappropriate ventilator settings
  - Unfitting interface
  - Excessive air leakage
  - Asynchrony with the ventilator
  - Poor tolerance to NIV
- After 60–90 min
  - No reduction in respiratory rate or carbon dioxide
  - No improvement in pH or oxygenation ($\downarrow SpO_2$ or $\downarrow PaO_2/FiO_2$)
  - Signs of fatigue
  - Neurological or underlying disease impairment

Criteria for endotracheal intubation

- Cardiac or respiratory arrest
- Progressive worsening of altered mental status
- Progressive worsening of pH, $PaCO_2$, or PaO_2 despite NIV
- Progressive signs of fatigue during NIV
- Need to protect the airway
- Persistent haemodynamic instability
- Agitation or intolerance to NIV with progressive respiratory failure

Non-invasive Ventilation Guidelines for Adult Patients with Acute Respiratory Failure 2014

7.	a) Initial settings for bi-level positive airway pressure (BPAP): inspiratory positive airway pressure (IPAP) of 10cmH_2O and expiratory positive airway pressure (EPAP) of 4-5cmH_2O= pressure support (PS) level of 5-6cm H_2O [3,5]. b) Initial settings for continuous positive airway pressure (CPAP): 5cmH_2O [3,5].	C
8.	Increases to IPAP of 2-5cmH_2O can be undertaken every 10 minutes or as clinically indicated until therapeutic response is achieved. The maximum IPAP should not exceed 20 – 23 cmH_2O [3].	C
9.	The target tidal volume of 6-8mls/kg (ideal body weight) is the target for all adult patients [4].	C
10.	Optimal non-invasive positive pressure ventilation (NIV) is the lowest pressure and lowest FiO_2 that achieve SaO_2 of 90% or PaO_2 of 60mmHg without further clinical deterioration [6].	Consensus

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Pratical aspects

- The key issue is optimal synchronization between the patient's spontaneous breathing and the ventilator
- Air leakage is often involved in case of asynchrony, which may be reduced by one or more of adjusting the mask, shortening inspiration time, changing pressure support by steps of 2 cm H_2O or moving inspiratory and expiratory triggers by steps of 5 – 10% or finally giving sedation
- In general a leak < 0.4/L/s may be tolerated (< 25L/min)

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Pratical aspects

The most important attribute of the equipment is leakage compensation through an increase in air flow (up to 120 – 180L/min)

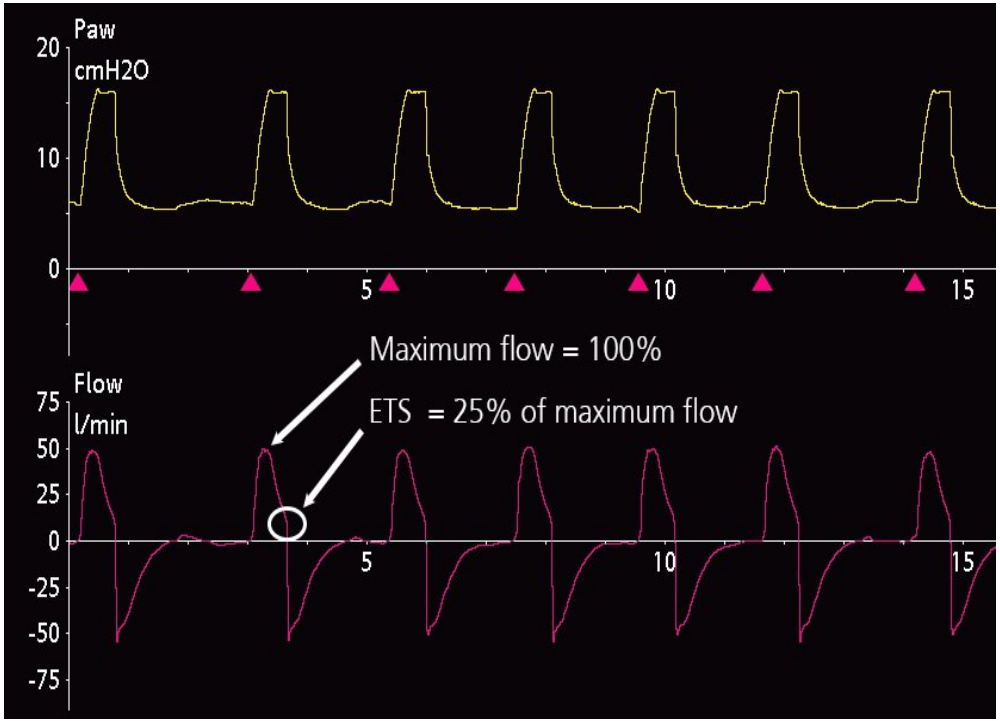
Ti max

If gas leakage is significant and the set cycle is not reached

BACK UP

The ventilator switches to exhalation when the set Ti max is reached so that inspiration can be termined

Expiratory trigger sensitivity (ETS)



Percent of peak inspiratory flow at wich the ventilator cycles from inspiration to exhalation

Increasing ETS setting ☾ shorter inspiratory time

Decrising ETS setting ☾ longer inspiratory time

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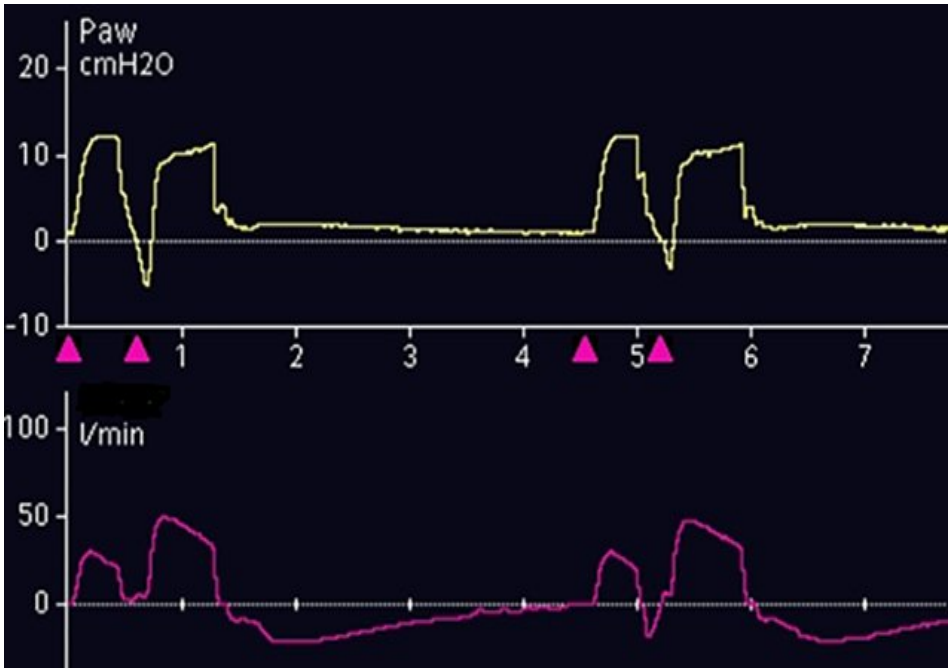
ASYNCHRONY

Ineffective efforts
Respiratory efforts not followed by a cycled response from the ventilator

Auto-triggering or double-triggering
Cycled respiration out of patients' demad

Tuning the Inspiratory trigger
Adjusting the level of Pressure Support

Double Triggering



- ✓ SHORT INSPIRATORY TIME
- ✓ INSUFFICIENT PRESSURE SUPPORT

PREMATURE CYCLING

INSPIRATORY MUSCLES COTINUE TO CONTRACT

THE VENTILATOR ANTICIPATE A SECOND EFFORT

HIGHER TIDAL VOLUME

HIGHER WORK OF BREATH

DECREASE ETS IN INCREMENTS OF 10% TO LENGHTEN THE INSPIRATORY TIME

ADJUST Ti max

INCREASE Psupport TO ACHIEVE THE DESIDERED TIDAL VOLUMES

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ASYNCHRONY

Prolonged cycle (delayed cycling off)
Cycled mechanical inspiratory time longer than patient's inspiratory time

Reduction of leakage
Decrease of Pressure Support, inspiratory time or ramp and, when available, titration of expiratory trigger

Auto-PEEP
Air trapping due to a limitation of the expiratory airflow
Osserved in COPD and cases with high respiratory rate

Extend expiratory time
Decrease respiratory rate
Titrate PEEP (compensate 80% of auto-PEEP in COPD patients

Delayed cycling

- ✓ ACTIVE EXPIRATORY EFFORT
- ✓ TIPICALLY DESCRIBED IN PATIENTS WITH BPCO

END INSPIRATORY PEAK IN THE PRESSURE CURVE

CHANGE IN THE SLOPE OF THE INSPIRATORY FLOW TOWARDS THE BASELINE

INCREASE ETS IN INCREMENTS OF 10% TO SHORTEN THE INSPIRATORY TIME

ADJUST Ti max

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When to stop

Non-invasive ventilation is usually stopped when a satisfactory recovery has been achieved (usually 2–5 h in ACPE) or conversely, if there are signs of NIV failure, requiring EI (*Table 5*). After mid- or long-term use of NIV (>24 h), a weaning[83] period is often carried out, by decreasing F_iO_2, PEEP, and ventilation settings progressively. Early mobilization may shorten this process. With F_iO_2 <0.5 and flow rate < 20 L/m, HFNC can be safely replaced by COT.


GRAZIE PER L'ATTENZIONE

European Heart Journal (2021) 42, 3599–3726

2021 ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure

OXYGEN THERAPY

- In AHF oxygen should not be used routinely in non-hypoxaemic patients as it causes vasoconstriction and a reduction in cardiac aoutput
- Oxygen therapy is recommended in patients with AHF and spO_2 <90% 0r paO_2 < 60 mmHg to correct hypoxaemia
- In COPD hyper-oxygenation may invrease ventilation-perfusion mismatch, suppress vemtilation and lead to hypercapnia
- During oxygen therapy acid-base balance and spO_2 should be monitored

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«We recommend that NIV should be used in patients with ACPE in order to reverse Respiratory Failure faster, avoid endotracheal intubation and (with lower evidence) reduce mortality in high risk patients. CPAP may be the best option in the pre-hospital setting».

INSUFFICIENZA RESPIRATORIA

Severa compromissione degli scambi gassosi ad esordio improvviso

Richieste metaboliche dell'organismo

insufficiente apporto di ossigeno ai tessuti

e/o

insufficiente rimozione dell'anidride carbonica nel sangue

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HFNC in critically ill patients, it is often started with a F_IO_2 of 100% and the maximum tolerated flow. Later, F_IO_2 and flow rate can be decreased according to SpO_2 [41] and patient's demand. In less severe cases, it is usually started with lower flow and F_IO_2.

Insufficienza Respiratoria

pO_2 indicates severity of respiratory failure

paO_2 (unlike pCO_2) is strongly influenced by shunting

Adequacy of ventilation defined by arterial pCO_2

In respiratory disease it is common for ventilatory failure and shunting to coexist in the same patient

Nunn

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ESC European Society of Cardiology
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Table 3 Main modalities of NIV

	Main characteristics	Advantages	Disadvantages	Main indication
CPAP	Continuous positive intra-thoracic pressure	Very simple use Does not require a ventilator Improves oxygenation	Does not provide ventilatory help on inspiration	ACPE Atelectasis Obstructive sleep apnoea
HFNC	High humidified flow (up to 60–80 L/m) through nasal cannula, producing: • Low level of PEEP • Decreased upper airway resistance • Tracheal air washout	Simple use Does not require a ventilator Good adaptation Improves oxygenation	Does not provide ventilatory help on inspiration	Sub-acute ACPE AHF needing prolonged NIV Hypoxaemic respiratory failure Weaning from mechanical ventilation
NIPSV	Inspiration: Decelerated flow to maintain a target pressure (pressure support) triggered by patient's effort. Expiration: PEEP	Provides ventilatory support Results as a continuous positive pressure plus a help on inspiration	Needs expertise and appropriate device. May produce overassistance when patients increase inspiratory effort	ACPE AHF and COPD Hypercapnic respiratory failure Weaning from mechanical ventilation

Noninvasive Ventilation and Oxygenation Strategies

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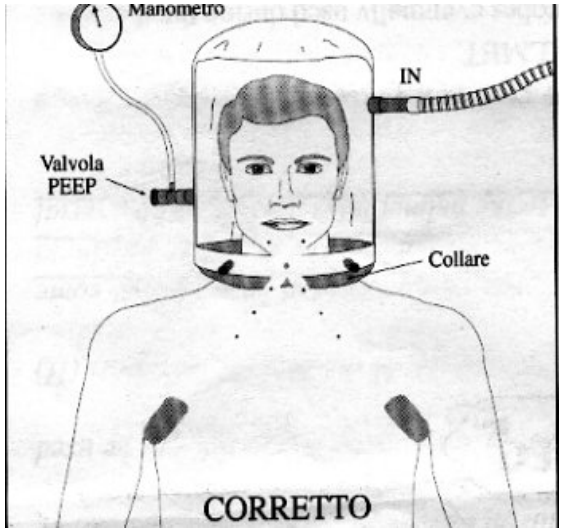

CPAP

- An increase in PEEP increases intrathoracic pressure, simultaneously increasing intrapleural pressure
- The difference between the left ventricle systolic pressure and intrapleural pressure determines the left ventricular afterload
- An increase in PEEP decreases left ventricular afterload and enhances cardiac

Insufficienza Respiratoria Ipossiemica (tipo I)

paO_2 < 60 mmHg
$PaCO_2$ N o ↓

A-a gradient < (age ÷ 4) + 4.

Alveoli ossigenati in maniera inadeguata

- ↓ FiO_2
- Collasso alveolare
- Riempimento alveolare (fluidi, sangue, cellule)

Compromissione transito di O_2 da alveoli al sangue

- Interstiziopatia
- Patologia vascolare polmonare

Compromissione del processo di Ossigenazione del sangue

- Ostruzione del flusso ematico
- Shunting
- Ridotti livelli di Hb o Emoglobinopatie