Respiratory Failure – how the respiratory physicians deal with airway emergencies

Dr Michael Davies MD FRCP
Consultant Respiratory Physician
Respiratory Support and Sleep Centre
Papworth Hospital NHS Foundation Trust

Physiology of respiratory failure
- Basics of acute respiratory support
- Non-invasive ventilation

The acutely ill patient with…
- COPD
- Asthma
- Morbid obesity
- The failing heart

Acute Respiratory Failure

Lung Failure
Hypoxaemia
\( \text{PaO}_2 < 8 \text{kPa} \)

Pump Failure
Hypercapnia
\( \text{PaO}_2 > 6 \text{kPa} \)

Hypoxaemia
\( \text{PaO}_2 < 8 \text{kPa} \)

OXYGEN TRANSPORT NOT TIGHTLY REGULATED

The oxygen cascade

Supplying more oxygen = easy
Improving Tissue Hypoxia = more complex

SUPPLY

Cardiac output

Oxygen

CPAP

Invasive ventilation

DELIVERY

functioning alveolar units

Hypoxia

Haemoglobin
Acute Respiratory Failure

Pump Failure

Hypercapnia

PaO₂ > 6kPa

PaCO₂ IS TIGHTLY REGULATED

Acute Respiratory Failure

Pump Failure

Hypercapnia

PaCO₂ IS TIGHTLY REGULATED

PUMP FAILURE

INCREASED RESPIRATORY LOAD

REDUCED MUSCLE CAPACITY

REDUCED NEURAL DRIVE

Pneumonia

Previously well

PaO₂ 6.1, PaCO₂ 8.1
pH 7.24, FiO₂ 15L

Intubate

Pneumonia

Duchenne Muscular Dystrophy

PaO₂ 6.9, PaCO₂ 8.7
pH 7.29, FiO₂ 15L

Physio ++ (cough-assist)
NIV

WHAT IS NON-INVASIVE VENTILATION?
What is non-invasive ventilation?

Pressure

Time

Pressure

Time

↑ alveolar ventilation

WHO MAY BENEFIT FROM NIV?

SIMPLE RULES OF THUMB TO ASSESS CHANCES OF SUCCESS

1. Pump failure > lung failure
2. Acute-on-chronic > Acute
3. If intubation greatly increases the risk of death.

 WHO MAY BENEFIT FROM NIV?

• Physiology of respiratory failure
  – Basics of acute respiratory support
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• The acutely ill patient with…
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MANAGEMENT OF ACUTE COPD

A paper that changed UK practice

THE LANCET

The early use of NIV for acute exacerbations of COPD.
(YONIV study)

Is NIV feasible in the real world?
Can it be performed successfully outside the ITU?

THE ACUTELY HYPERCAPNIC COPD PATIENT

Severity, risk stratify, other causes (PE!)
Controlled oxygen therapy
  Improve hypoxaemia first, then CO₂. Repeat ABGs.
Bronchodilators, Corticosteroids
Antibiotics
  If increased sputum volume/purulence
Respiratory specialist care
Non-invasive ventilation
The ceiling of therapy? – avoid therapeutic nihilism!
Discharge planning
  Rehabilitation
  Home ventilatory support?
Why it is important

Control  NIV

0  10  20  30  40  50

Treatment failure

In-hospital mortality

NIV CAN BE DELIVERED ON THE WARD.

Why it is important

Control  NIV

0  10  20  30  40  50

Treatment failure

In-hospital mortality

Treatment failure

In-hospital mortality

Why it is important

GREATER BENEFIT IN "MILD" ACIDOSIS.

pH > 7.3  pH < 7.3

0  10  20  30  40  50

Treatment failure

In-hospital mortality

EARLY NIV IN ACUTE HYPERCAPNIC COPD SAVES LIVES, DECREASES HOSPITAL STAY AND COSTS LESS MONEY THAN STANDARD CARE

- Decrease in mortality 48%
- Decreased rate of intubation 59%
- Decreased hospital stay 3 days

Ram FSF et al. Cochrane Database of Systematic Reviews 2004.

What proportion of COPD patients need NIV?

Not acidotic (75%)

Acidotic (20%)

Not acidotic on repeat ABG (5%)


What proportion of COPD patients receive NIV?

Acidotic (20%)

Roberts CM et al. Thorax 2011

What proportion of COPD patients receive NIV?

Roberts CM et al. Thorax 2011

British Thoracic Society NIV Audit 2010

Data collected from 925 admissions in 61 UK Hospitals (Feb – March 2010)
COPD >> Acute Pulmonary oedema >>> Other
Radiological consolidation in 34%

British Thoracic Society NIV Audit 2010

Treatment plans

<table>
<thead>
<tr>
<th>Treatment plans</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>49% NIV as ceiling</td>
<td>27% NIV unsuccessful</td>
</tr>
<tr>
<td>14% would intubate</td>
<td>2.3% later intubated</td>
</tr>
<tr>
<td>5% palliative intent</td>
<td></td>
</tr>
</tbody>
</table>

Discussed with…

<table>
<thead>
<tr>
<th>% ITU</th>
<th>% patient / relative</th>
<th>% supervising cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>30%</td>
<td>36%</td>
<td>30%</td>
</tr>
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</table>

27% no follow up plan
23% LTOT
9% home NIV

Learning from Cardiology?

<table>
<thead>
<tr>
<th>AECOPD</th>
<th>ACUTE MI (75 yrs)</th>
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<tbody>
<tr>
<td>10%</td>
<td>10%</td>
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</table>

Mortality
One year survival
Risk Stratification?
Effective treatment?
Discharge meds
Rehabilitation
Attitudes
Patient awareness

10%
25%
Rarely
Yes
No plan
Evidence, patchy
Nihilism
? / “exasperation”

What does “an acute exacerbation of COPD” mean to patients and physicians?

THE ACUTELY HYPERCAPNIC COPD PATIENT

Severity, risk stratify, other causes (PE!)
Controlled oxygen therapy
  Improve hypoxaemia first, then CO2. Repeat ABGs.
Bronchodilators, Corticosteroids
Antibiotics
  If increased sputum volume/purulence
Respiratory specialist care
Non-invasive ventilation
The ceiling of therapy? – avoid therapeutic nihilism!
Discharge planning
  Rehabilitation
  Home ventilatory support!
ACUTE NIV IN CONDITIONS OTHER THAN COPD

Clear benefit in COPD, but who else?

Severe (hypoxaemic) respiratory failure

Intubation increases morbidity and mortality

Avoid intubation

NIV prevents need for intubation

Improve morbidity and mortality?

NIV usually no benefit when used in Hypoxaemic Respiratory Failure

NIV IS UNLIKELY TO HELP A PATIENT WITH ACUTE SEVERE PNEUMONIA.

EXCEPTION: Pneumonia in the immunocompromised [RESPIRATORY DIALYSIS!]

Acute hypoxaemic respiratory failure + fever + infiltrates.

<table>
<thead>
<tr>
<th></th>
<th>Standard treatment (n=26)</th>
<th>Standard treatment plus NPPV (n=26)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment failure (intubation)</td>
<td>77%</td>
<td>46%</td>
<td>0.03</td>
</tr>
<tr>
<td>In-hospital mortality</td>
<td>81%</td>
<td>50%</td>
<td>0.02</td>
</tr>
</tbody>
</table>

Worst outcomes in haematological malignancy + neutropaenia.

Hilbert G et al. NEJM 2001; 344(7):481-487

NIV failure may cause harm

- Creating an inappropriate ceiling of therapy
  Wildman et al.2007. BMJ 335: 1132

- Delaying intubation
  Demoule A et al. 2006 ICM 32; 1756-65
MANAGEMENT OF LIFE-THREATENING ASTHMA

LIFE-THREATENING ASTHMA
Steroids! Pred 40 mg po AND Hydrocort 200mg iv
Continuous nebulised Salbutamol & 4° Ipratropium
Antibiotics +/- po Tamiflu (if <48hr of flu symptoms)
Fluid resuscitation
Magnesium, but benefit only in very severe attacks
Aminophylline can be life-saving

NIV in acute severe asthma?

NOT RECOMMENDED BEYOND BRIEF TRIAL IN ITU BY EXPERIENCED SPECIALISTS.
SMALL SCALE CLINICAL STUDY ONLY.
Soroksky A et al. Chest 2003

ACUTE NIV IN THE MORBIDLY OBESE PATIENT


Percentage of adult population with a BMI > 30

Obesity-related acute respiratory failure – THINK OF SLEEP-DISORDERED BREATHING

Acute hypercapnic respiratory failure
Infection?
PE?
Cardiac?
Pre-existing COPD?
Previously unrecognised sleep-disordered breathing?
Hypoventilation is common in the obese and not usually recognised.


PaCO$_2$ less than 6 kPa 18 month mortality 9%

PaCO$_2$ more than 6 kPa (31%) 18 month mortality 23%

150 consecutive medical admissions no prior lung disease

↑PaCO$_2$ with ↑BMI

RESPIRATORY SUPPORT IN LIFE-THREATENING ACUTE HEART FAILURE

Ventilatory support for the failing heart?

↓Pre-load

↑Alveolar recruitment

↑Functional Residual Capacity

↓After-load

Inspiratory muscle unloading

NIV for acute pulmonary oedema?

Noninvasive Ventilation in Acute Cardiogenic Pulmonary Edema

Alexander Gray, M.D., Steve Czerniecki, Ph.D., David E. Newey, M.D., Maria Mazzio, M.Sc., Fiona Sarpay, M.Sc., and Jon Mitchell, M.Sc., for the 3CPO Study Group

3CPO STUDY RESULTS

• More rapid resolution of metabolic abnormalities and respiratory distress.

• No change in 7-day or 30-day mortality.

• CPAP or NIV similar.

CPAP usually easier.

Gray A et al. NEJM 2008; 359:142-51
Acute pulmonary oedema vs. acute-on-chronic exacerbation of heart failure

\[
\begin{array}{c}
\text{Sys.BP >140} \\
\text{Sys.BP 100 -140} \\
\text{Sys.BP <100}
\end{array}
\]

CPAP / NIV
Nitrates
No diuretics

Nitrates
CPAP / NIV
Diuretics

Fluid chall.?
Inotropes / Pressors

Chatti R et al Heart Fail Rev 2007

Summary

- Physiology of respiratory failure
  - Basics of acute respiratory support
  - Framework for appropriate treatment

- The acutely ill patient with...
  - AECOPD (acute lung attack)
  - Asthma
  - Morbid obesity
  - The acutely failing heart

CONCLUSIONS

- Applying acute MI management principles would improve the outcomes of “acute lung attacks.”

- The NIV revolution has
  - Improved acute COPD care.
  - Exposed some patients to risk.

- Providing an acute NIV service properly needs
  - Investment but is cost-effective
  - Integration with other departments

NIV for acute respiratory failure

- Good evidence
- Acute hypercapnic COPD
- Infection in immunocompromised
- Obesity-related ventilatory failure
- Acute cardiopulmonary oedema
- TRAIALS OF NIV
- Post-extubation ventilatory failure
- Acute hypoxaemic resp failure
- Acute asthma – clinical trial needed

- CPAP

ITU only – caution!

ADDITIONAL CONTENT

The following slides do not form part of the presentation but are included for completeness. Starting a patient upon NIV is a straightforward process but there is no substitute for actually doing this. If you are responsible for patients with respiratory failure on the acute take, then I would strongly urge you to take the time to do this.

WHAT MACHINE? LESS IMPORTANT THAN EXPERTISE

- VPAP I (YONIV study)
- Most NIV (current)
- Complex NIV (future)

- Pressure Support
- Pressure Control
- Volume-assured
WHAT MASK?
- Any full face mask in the acute situation.
- Standard masks
- Total full face masks
- Helmets – good for pre-hospital and post-operative CPAP

HOW TO START NON-INVASIVE VENTILATION
- Team expertise, staffing levels, location.
- Practical teaching - if you are expected to do something, you should have appropriate training.
- Set-up the kit away from the patient.
- Encourage slower breathing to coordinate with the ventilator.
- You are trying to reduce anxiety and prevent rapid shallow breathing. This would cause failure to trigger ventilation and poor tolerability. Simply reducing the trigger sensitivity may cause auto-triggering.

HOW TO START NON-INVASIVE VENTILATION
- Start at low settings (IPAP 12, EPAP 4) and work up.
- You are aiming to reduce acidosis / hypercapnia. Increasing pressure (IPAP) will increase the volume applied and reduce CO2.
- Watch closely at the start
  - Has chest wall movement improved?
  - Repeat ABGs. Have you improved ventilation?

NIV makes sense in hypercapnia

\[
\text{PaCO}_2 = \left( \frac{\text{VCO}_2}{\text{VA}} \right)k
\]

INCREASED RESPIRATORY LOAD
- Reduced muscle capacity
- Reduced neural drive

NIV less likely to reverse hypoxia
(hypoventilation not typical cause of hypoxia)

\[
\text{PAO}_2 = \text{PIO}_2 - \left( \frac{\text{PACO}_2}{\text{RQ}} \right)
\]

\(\text{PIO}_2\) = partial pressure of inspired \(\text{O}_2\)

- V/Q inequality
- Shunt
- Hypoventilation
- Diffusion defect
- Cardiac output
- \(\frac{1}{n}\) functioning alveolar units
- Hypoxia
- Haemoglobin

\(\text{PAO}_2\) = partial pressure of arterial \(\text{O}_2\)

\(\text{PiO}_2\) = partial pressure of inspired \(\text{O}_2\)

\(\text{PACO}_2\) = partial pressure of arterial \(\text{CO}_2\)

\(\text{RQ}\) = respiratory quotient