Recent publications.
NIV in acute hypercapnic respiratory failure.

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With an introduction by Enrico M.Clini, MD

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Introduction.

Non-invasive ventilation (NIV) is a therapy with proven efficacy used worldwide; hypercapnic exacerbations of chronic obstructive pulmonary disease (COPD) and cardiogenic pulmonary oedema are the most important indication for NIV. Hypoxic respiratory failure and facilitation of weaning are infrequent conditions for which NIV should be routinely instituted, preferably at specialised centres.

 Although the use of NIV varies greatly among hospitals and countries, it has almost doubled (from about 5 to 11%) in the last 10 years. In Europe and North America, the rate of NIV use in the emergency setting ranges from 35% to around 60% of all the ventilatory treatments. However, nowadays, NIV use has also spread to settings outside of emergency departments, such as specialty wards and palliative care units. Overall, the success rate of this technique during acute respiratory failure not only depends on the underlying diagnosis and patient characteristics, but also on its timing, wherein the early application of NIV presents an ideal opportunity to not delay intervention before the patient’s condition progresses.

Patients with acute respiratory acidosis caused by an exacerbation of COPD are the group that benefits most from NIV. Compared with standard medical therapy alone, NIV may improve survival, reduce the need for endotracheal intubation, lower the rate of complications (such as hospital-acquired pneumonia or difficult weaning) and shorten stays in the hospital and intensive care unit.

Even when used on the ward, early use of NIV in COPD patients may obviate endotracheal intubation and improve survival, as compared with medical therapy, particularly in patients whose respiratory acidosis is characterised by a pH between 7.34 and 7.305. Candidates outside the intensive care setting suffering from this clinical condition generally show a low risk for NIV failure (10% to 20%) as reported in several trials, suggesting that NIV may be safely administered in this setting as the ventilatory strategy of choice, even in highly compromised and elderly individuals. In addition, NIV has been successfully used as a long-term intervention in COPD patients following episodes of acute acidotic respiratory failure, thus reducing their probability of clinically deteriorating over time.

Whereas patients with lower pH levels are still candidates for the early use of NIV, they should preferably be transferred to a closely monitored unit. Apparently, encephalopathy with altered levels of consciousness due to hypercapnic acute respiratory failure (such as during acute exacerbation of COPD) is not a strict contraindication for NIV, although the condition should be regarded with great caution when administering NIV and not considered for routine clinical practice.

A staff highly experienced in the technique and ready to access the airway by endotracheal intubation is required to manage NIV patients with severe hypercapnic respiratory acidosis (i.e., pH < 7.10). Conditions that may prompt intubation include haemodynamic instability, inadequate oxygenation and loss of cooperation during NIV. Delayed intubation in these patients runs the risk of unanticipated respiratory or cardiac arrest leading to increased morbidity and mortality. Factors predicting NIV failure at different risk rates in hypercapnic respiratory insufficiency are no change or fall in pH, no change or rise in respiratory rate 2 hours post NIV application, higher level of illness as assessed by severity scores at admission and lack of patient cooperation.

In acute settings, the use of early NIV has been tested in patients with acute and hypercapnic respiratory failure due to severe community-acquired pneumonia (CAP), including patients with COPD. The subgroup analysis clearly showed that only patients with COPD benefit. Indeed, observational studies suggest that NIV and the subsequent delay in endotracheal intubation may actually be harmful in hypoxaemic acute respiratory failure caused by CAP in the absence of COPD.

Key Points

⇒ NIV is recognised worldwide as a modality to assist ventilation during early phase of hypercapnic respiratory failure to avoid endotracheal intubation and prevent mortality
⇒ Delivery of NIV in this condition is effective in critical care areas as well as on the ward, but caution and strict monitoring are advised in patients with unbeneficial acr- doss
⇒ Deterioration of pH and respiratory rate, a lack of patient cooperation within 2 hours of NIV use and a higher severity score at admission are predictive of NIV failure

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RATIONALE: The use of non-invasive ventilation (NIV) as an early weaning/extubation technique from mechanical ventilation remains controversial.

OBJECTIVES: To investigate NIV effectiveness as an early weaning/extubation technique in difficult-to-wean patients with chronic hypercapnic respiratory failure (CHRF).

METHODS: In 13 intensive care units, 208 patients with CHRF intubated for acute respiratory failure (ARF) who failed a first spontaneous breathing trial were randomly assigned to three groups: conventional invasive weaning group (n=69), extubation followed by standard oxygen therapy (n=70), or NIV (n=69). NIV was permitted as rescue therapy for both non-NIV groups if postextubation ARF occurred. Primary endpoint was reintubation within 7 days after extubation. Secondary endpoints were: occurrence of postextubation ARF or death within 7 days after extubation, use of rescue postextubation NIV, weaning time, and patient outcomes.

MEASUREMENTS AND MAIN RESULTS: Reintubation rates were 30, 37, and 32% for invasive weaning, oxygen-therapy, and NIV groups, respectively (P=0.654). Weaning failure rates, including postextubation ARF, were 54, 71, and 33%, respectively (P=0.001). Rescue NIV success rates for invasive and oxygen-therapy groups were 45 and 58%, respectively (P=0.386). By design, intubation duration was 1.5 days longer for the invasive group than in the two others. Apart from a longer weaning time in NIV than in invasive group (2.5 vs. 1.5 d; P=0.033), no significant outcome difference was observed between groups.

CONCLUSIONS: No difference was found in the reintubation rate between the three weaning strategies. NIV decreases the intubation duration and may improve the weaning results in difficult-to-wean patients with CHRF by reducing the risk of postextubation ARF. The benefit of rescue NIV in these patients deserves confirmation. Clinical trial registered with www.clinicaltrials.gov (NCT 00213499).

PMID: 21680944 [PubMed – indexed for MEDLINE]


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OBJECTIVE: Older patients usually receive less invasive and costly hospital care, even if they meet the criteria for Intensive Care Unit admission or have a ‘do not intubate’ (DNI) order. The aim of this randomised, controlled trial was to assess the effectiveness of non-invasive mechanical ventilation (NIV) versus the standard medical therapy (SMT) in reducing the need of intubation, improving survival and reducing respiratory distress in very old patients with acute hypercapnic respiratory failure (AHRF).

PARTICIPANTS AND DESIGN: Eighty-two patients aged >75 years (mean age 81.3 ± 3.5 years) were randomised to receive NIV or SMT.

SETTINGS: Three respiratory units.

MEASUREMENTS: The primary outcome was the rate of meeting the endotracheal intubation (ETI) criteria. Secondary outcomes were the mortality rate, the respiratory rate, dyspnoea score, arterial blood gases. Results: the rate of meeting the ETI criteria was lower in the NIV group compared with the SMT group (7.3 versus 63.4%, respectively; P<0.001), as was the mortality rate [(odds ratios) OR = 0.40; 95% CI: 0.19–0.83; P=0.014]. Twenty-two of 41 SMT patients with DNI orders received NIV as a rescue therapy. The mortality rate in this subgroup was comparable with the NIV group and significantly lower compared with patients receiving ETI (OR=0.60, 95% CI: 0.18–1.92 versus 4.03, 95% CI: 2.35–6.94, respectively, P=0.009). Arterial blood gases, respiratory rate and dyspnoea improved significantly faster with NIV than with SMT.

CONCLUSIONS: Compared with SMT, NIV decreased the rate of meeting the ETI criteria and the mortality rate of very old patients with AHRF. NIV should be offered as an alternative to patients considered poor candidates for intubation and those with a DNI order.

PMID: 21345841 [PubMed – indexed for MEDLINE]
Abstract. Long-term non-invasive ventilation in COPD after acute-on-chronic respiratory failure.

BACKGROUND: COPD patients who remain hypercapnic after acute respiratory failure requiring mechanical ventilation have a poor prognosis. Long-term nocturnal non-invasive ventilation (NIV) may be beneficial for these patients. We hypothesized that stable patients on long-term NIV would experience clinical worsening after withdrawal of NIV.

METHODS: We included 26 consecutive COPD patients (63 ± 6 years, 58% male, FEV₁ 31 ± 14% predicted) who remained hypercapnic after acute respiratory failure requiring mechanical ventilation. After a six month run-in period, during which all patients received NIV, they were randomised to either continue (ventilation group, n=13) or to stop NIV (withdrawal group, n=13). The primary endpoint was time to clinical worsening defined as an escalation of mechanical ventilation.

RESULTS: All patients remained stable during the run-in period. After randomisation the withdrawal group had a higher probability of clinical worsening compared to the ventilation group (p=0.0018). After 12 months, ten patients (77%) in the withdrawal group, but only two patients (15%) in the ventilation group, experienced clinical worsening (p=0.0048). Six-minute walking distance increased in the ventilation group.

CONCLUSION: COPD patients who remain hypercapnic after acute respiratory failure requiring mechanical ventilation may benefit from long-term NIV.

PMID: 21111590
[PubMed – indexed for MEDLINE]

Abstract. The influence of severe obesity on non-invasive ventilation (NIV) strategies and responses in patients with acute hypercapnic respiratory failure attacks in the ICU.

BACKGROUND: Obesity rates are increasing in the general population and are also prevalent in intensive care units (ICUs). Patients are sometimes admitted to ICUs for hypercapnic respiratory failure or cor pulmonale, but more often, they are admitted for pneumonia, excessive daytime sleepiness, heart failure, chronic obstructive pulmonary disease (COPD), asthma attacks or pulmonary embolism, and hypercapnic respiratory failure is coincidentally noticed during this period. The optimal non-invasive mechanical ventilation strategy is often not used during ICU treatment. The aim of this study was to assess the differences between non-invasive ventilation (NIV) strategies and the outcomes of obese and non-obese patients with acute hypercapnic respiratory failure.

METHODS: In this retrospective cohort study, 73 patients who were ventilated with a face mask were studied. Patients were divided into two groups: obese (BMI >35 kg/m²) and non-obese (BMI <35 kg/m²), and the differences between these two groups in necessary pressure, volume, mode, ventilator and time to reduce PaCO₂ below 50 mmHg were investigated.

RESULTS: The mean age of the patients was 66 (plus or minus) 14 years, and the mean admission APACHE II score was 18 (plus or minus) 4. Forty-one (56%) of the patients were female. For the obese patients, the reason for ICU admission was more frequently pulmonary edema and less frequently pulmonary infections, which was significantly different (P=0.003 and 0.043, respectively) than the rates for the non-obese patients. While there was no significant difference across the groups between the ventilators, modes and inspiratory pressure levels, obese patients required higher end-expiratory pressure levels and more time to reduce their PaCO₂ levels below 50 mmHg than non-obese patients. The lengths of NIV and ICU stay and intubation and the mortality rates were similar in both groups.

CONCLUSION: These results suggest that improvement in hypercapnia in obese patients may require higher PEEP levels and longer times than that of non-obese patients during acute hypercapnic respiratory failure attack.

PMID: 21273965
[PubMed – indexed for MEDLINE]
Abstract. Poor sleep quality is associated with late non-invasive ventilation failure in patients with acute hypercapnic respiratory failure.

OBJECTIVE: To determine whether sleep quality helps to predict non-invasive ventilation outcome in patients with acute hypercapnic respiratory failure. Despite an initial clinical improvement, nearly one fourth of patients may fail non-invasive ventilation after several days. Because late intubation is associated with a poor prognosis, it may be useful to identify factors that may predict or explain late non-invasive ventilation failure.

PATIENTS: We prospectively studied 27 hypercapnic patients in a medical intensive care unit who required non-invasive ventilation for >48 hrs.

INTERVENTIONS: A 17-hr sleep polysomnography (3 pm-8 am) was recorded 2 days to 4 days after non-invasive ventilation initiation. Late non-invasive ventilation failure was defined as death, endotracheal intubation, or persistent need for non-invasive ventilation on day 6.

MEASUREMENTS AND MAIN RESULTS: An abnormal electroencephalographic pattern that eluded analysis by standard sleep-scoring criteria was noted in seven (50%) of the 14 patients with late non-invasive ventilation failure compared with one (8%) of the 13 patients successfully treated with non-invasive ventilation (p=0.03). No clinical or laboratory variables explained the electroencephalographic differences. Patients failing non-invasive ventilation had poorer sleep quality with greater circadian sleep-cycle disruption and less nocturnal rapid eye movement sleep (6 mins [range, 0–12] vs. 26 mins [range, 6–49], p=0.03), compared with patients successfully treated with non-invasive ventilation. Non-invasive ventilation failure was associated with delirium during the intensive care unit stay (64% vs. 0%).

CONCLUSIONS: Late non-invasive ventilation failure in elderly patients with acute hypercapnic respiratory failure was associated with early sleep disturbances including an abnormal electroencephalographic pattern, disruption of the circadian sleep cycle, and decreased rapid eye movement sleep.

PMID: 19789439
[PubMed – indexed for MEDLINE]

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OBJECTIVE: A case series evaluating the acute effects of non-invasive positive pressure ventilation (NPPV) in patients with chronic hypercapnic respiratory failure (HRF) secondary to interstitial lung diseases (ILD).

PATIENTS AND METHODS: Ten patients with ILD were retrospectively evaluated. All had restrictive lung function (mean TLC, 47.6 ± 12.6% predicted) and chronic hypercapnic respiratory failure (mean pH=7.39 ± 0.02). Arterial blood gas analysis and lung function were compared before and after the application of controlled pressure-limited NPPV.

RESULTS: Daytime PaCO₂ during spontaneous breathing decreased by 5.4 ± 1.3 mmHg (95% confidence interval, 4.5–6.3), from 57.7 ± 5.1 mmHg to 52.3 ± 5.9 (p=0.001), while daytime PaO₂ increased by 3.4 ± 3.3 mmHg (95% confidence interval, 1.0–5.8), from 63.7 ± 3.5 mmHg to 67.1 ± 3.4 (p=0.01), and TLC increased by 3.9 ± 4.5% (95% confidence interval, 0.7–7.1), from 47.6 ± 12.6% mmHg to 51.5 ± 10.0% (p=0.023).

CONCLUSIONS: In patients with ILD and chronic HRF controlled NPPV is tolerated and can acutely improve blood gas levels. Further studies examining the long-term benefits need to be explored.

PMID: 19454410
[PubMed – indexed for MEDLINE]

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Abstract. Hyperglycaemia as a predictor of outcome during non-invasive ventilation in decompensated COPD.

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RATIONALE: Hyperglycaemia predicts a poor outcome in Intensive Care Unit (ICU) patients. Whether this is true for respiratory failure necessitating non-invasive ventilation (NIV) is not known.

OBJECTIVES: To determine whether hyperglycaemia within 24 h of admission independently predicts outcome of NIV during acute decompensated ventilatory failure complicating chronic obstructive pulmonary disease (COPD) exacerbations.

METHODS: Patients with COPD presenting with acute hypercapnic respiratory failure at University Hospital Aintree between June 2006 and September 2007 and receiving NIV within 24 h of admission were studied prospectively. Random blood glucose levels were measured before NIV administration.

RESULTS: 88 patients (mean baseline pH 7.25, PaCO₂ 10.20 kPa, and PaO₂ 8.19 kPa) met the inclusion criteria, with NIV normalising arterial pH off therapy in 79 (90%). After multivariate logistic regression, the following predicted outcome: baseline respiratory rate (OR 0.91; 95% CI 0.84 to 0.99), random glucose ≥ 7 mmol/l (OR 0.07; 95% CI 0.007 to 0.63) and admission APACHE II (Acute Physiology and Chronic Health Evaluation II) score (OR 0.75; 95% CI 0.62 to 0.90). The combination of baseline respiratory rate (RR) <30 breaths/min and random glucose <7 mmol/l increased prediction of NIV success to 97%, whilst use of all three factors was 100% predictive.

CONCLUSIONS: In acute decompensated ventilatory failure complicating COPD, hyperglycaemia is an important predictor of outcome. Baseline RR and hyperglycaemia are as good at predicting clinical outcomes as the APACHE II score. Combining these variables increases predictive accuracy, providing a simple method of early risk stratification.

PMID: 19454410
[PubMed – indexed for MEDLINE]

Abstract. Impact of non-invasive ventilation (NIV) trial for various types of acute respiratory failure in the emergency department; decreased mortality and use of the ICU.

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BACKGROUND: Trial of non-invasive ventilation (NIV) in the emergency department (ED) for heterogeneous acute respiratory failure (ARF) has been optional and its clinical benefit unclear.

METHODS: We conducted a retrospective cohort study comparing between two periods, October 2001-September 2003 and October 2004-September 2006, i.e., before and after adopting an NIV-trial strategy in which NIV was applied in the ED to any noncontraindicated ARF patients needing ventilatory support and was then continued in the intermediate-care-unit. During these two periods, we retrieved cases of ARF treated either invasively or with NIV, and compared the patients’ in-hospital mortalities and the length of ICU and intermediate-care-unit stay.

RESULTS: Compared were 73 (invasive 56; NIV 17) and 125 cases (invasive 31, NIV 94) retrieved from 271 and 415 emergent admissions with proper pulmonary etiologies for mechanical ventilation, respectively. Of their respiratory failures, type (hypercapnic/non-hypercapnic, 8.97 vs. 0.98) and severity (pH 7.23 vs. 7.21 for hypercapnic; PaO₂/FiO₂ 133 vs. 137 for non-hypercapnic) were similar, and the rate of predisposing etiologies was not significantly different. However, excluding those with recurrent aspiration pneumonia for whom NIV was mostly used as “ceiling” treatment, significant reductions in both overall in-hospital mortality (38% vs. 19%, risk ratio 0.51, 95% CI 0.31–0.84), and median length of ICU and intermediate-care-unit stay (12 vs. 5 days, P<0.0001) were found.

CONCLUSIONS: NIV-trial in the ED for all possible patients with ARF of pulmonary etiologies, excluding those with recurrent aspiration pneumonia, may reduce overall in-hospital mortality and ICU stays.

PMID:18804357
[PubMed – indexed for MEDLINE]
Abstract. Interface strategy during non-invasive positive pressure ventilation for hypercapnic acute respiratory failure.

OBJECTIVE: To assess the influence of initial mask choice on the clinical effectiveness and tolerance of non-invasive positive pressure ventilation (NIPPV) in the management of hypercapnic acute respiratory failure.

DESIGN: A prospective randomized controlled clinical study.

SETTING: A medical intensive care unit at a university hospital.

INTERVENTION: Randomization between two NIPPV interfaces.

PATIENTS: Initial mask choice was randomized between two standard masks: face (NIPPVf group) and nasal (NIPPVn group). The main end point was mask failure (i.e., mask change and/or intubation). Secondary end points were tolerance of NIPPV, change in respiratory parameters during the first 3 days, and patient outcome. Results were analyzed on an intent to treat basis. A per protocol analysis was also conducted.

MAIN RESULTS: Ninety patients with underlying chronic lung disease were included, 46 in the NIPPVf group and 44 in the NIPPVn group. The overall success rate of NIPPV was 83%. Mask failure occurred significantly more often in the NIPPVn group (32/44 vs. 9/46; p<0.0001), mainly because of the need for mask change (32/44 vs. 0/46; p<0.0001) because of the occurrence of major buccal air-leaks in 94% of cases. Improvement in respiratory parameters was similar in the two groups. Whereas air-leaks were more frequent in the NIPPVn group (p<0.05), respiratory comfort was assessed as lower and complications more frequent by the staff in the NIPPVf group from day 2 (p<0.05).

CONCLUSIONS: A face mask should be the first-line strategy in the initial management of hypercapnic acute respiratory failure with NIPPV. However, if NIPPV has to be prolonged, switching to a nasal mask may improve comfort by reducing face mask complications.

PMID:19050635 [PubMed – indexed for MEDLINE]

Abstract. Non-invasive positive-pressure ventilation in acute respiratory failure outside clinical trials: Experience at the Massachusetts General Hospital.

BACKGROUND: Non-invasive positive-pressure ventilation (NIPPV) has been shown to be effective in select patients enrolled in clinical trials. However, few data are available on the use of NIPPV as routine standard medical care for patients with respiratory failure outside of controlled trials.

MEASUREMENTS AND MAIN RESULTS: All patients receiving NIPPV for a 1-yr period for acute or acute on chronic respiratory failure who did not select do not intubate/resuscitate status were evaluated. Demographic, physiological, and laboratory data were collected for as long as NIPPV was provided. Data were recorded on 449 patients. Intubation rate was 18%, 24%, 38%, 40%, and 60%, respectively, for patients with cardiogenic pulmonary edema (n=97), acute exacerbation of chronic obstructive pulmonary disease (n=97), acute exacerbation of chronic obstructive pulmonary disease acute hypercapnic respiratory failure (n=35), postextubation respiratory failure patients (n=95), and acute hypoxemic respiratory failure (n=144). The hospital mortality for patients with acute hypoxemic respiratory failure who failed NIPPV was 64%. A logistic regression showed that baseline Simplified Acute Physiology Score II (odds ratio [OR], 1.07; 95% confidence interval [CI], 1.05–1.10; p<0.0001), Glasgow Coma Scale (OR, 0.76; 95% CI, 0.66–0.87; p<0.0001), PaO₂/FiO₂ ratio (OR, 0.98; 95% CI, 0.93–0.99; p<0.02), and serum albumin (OR, 0.31; 95% CI, 0.16–0.57; p<0.001) were the variables associated with NIPPV failure.

CONCLUSION: NIPPV as routine standard medical care resulted in the intubation of a similar percentage of patients with respiratory failure due to cardiogenic pulmonary edema and chronic obstructive pulmonary disease exacerbation as shown in randomized controlled trials but in a higher percent of patients with hypoxemic respiratory failure than reported in these trials. NIPPV failure was associated with high hospital mortality for patients with hypoxemic respiratory failure.

PMID:18091340 [PubMed – indexed for MEDLINE]
Abstract. Non-invasive assisted pressure-controlled ventilation: As effective as pressure support ventilation in chronic obstructive pulmonary disease?

BACKGROUND: Non-invasive ventilation (NIV) is being increasingly used in hypercapnic chronic obstructive pulmonary disease (COPD) patients but the most appropriate ventilation mode is still not known.

OBJECTIVES: The aim of this study was to investigate if assisted pressure-controlled ventilation (APCV) can be a better alternative to pressure-support ventilation (PSV) for NIV in COPD patients with acute hypercapnic respiratory failure (AHRF).

METHODS: In this prospective randomized study, we evaluated the early effects of non-invasive APCV and PSV in 34 consecutive COPD patients with AHRF. Patients were randomized into 1 of the 2 modes, and respiratory and hemodynamic values were compared before and after 1 h of NIV.

RESULTS: Baseline values did not differ between the 2 groups. There were significant improvements in partial arterial carbon dioxide pressure and pH levels in the APCV group when compared with baseline (p<0.05). Cardiac output and cardiac index decreased in both groups (p<0.05) but more significantly in the PSV group (p<0.0001). The decreases in stroke volume index and increases in arterial oxygen content after NIV were also considerable in both groups (p<0.05). Central venous pressure and systemic vascular resistance index values increased notably only after PSV (p<0.05).

CONCLUSIONS: From these data, we deduce that APCV can be a better alternative to PSV for NIV in COPD patients with AHRF owing to its more beneficial physiological effects.

PMID: 17627100
[PubMed – indexed for MEDLINE]