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

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See Editorial, p 830

► Additional tables and details of local protocols and of the six cases where COPD was diagnosed clinically are published online only at http://thorax.bmj.com/content/vol64/issue10

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ABSTRACT

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, $PaCO_2$ 10.20 kPa, and PaO_2 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 upon presentation was associated with a poor 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.

Non-invasive ventilation (NIV) is an effective treatment for acute hypercapnic respiratory failure (AHRF) complicating a chronic obstructive pulmonary disease (COPD) exacerbation.[1] However, some patients do not improve with NIV and in these individuals endotracheal intubation or, where appropriate, palliation are needed. Several factors are associated with an increased risk of NIV failure. In one randomised controlled trial survival was worse when the initial pH was below 7.3, or if $PaCO_2$ or the respiratory rate (RR) failed to improve after 4 h of treatment.[2] Other factors retrospectively identified as poor prognostic markers include a high APACHE II (Acute Physiology and Chronic Health Evaluation II) score, radiologically confirmed consolidation, haemodynamic instability, impaired consciousness, the presence of comorbidities, impaired functional status and metabolic dysfunction.[3–5] NIV is now offered to patients with COPD presenting with more severe acidosis than in these early clinical trials and appears to be effective in improving clinical outcomes.[6] Whether the same risk factors operate and do so to the same degree is not clear.

In patients with a wide range of conditions admitted to intensive care, pretherapy hyperglycaemia is an independent predictor of a poor outcome[7–10] which may be improved by tight glycaemic control.[11 12] A retrospective case note review of patients hospitalised with COPD exacerbations but not necessarily exhibiting respiratory failure found an increased mortality and longer hospital stay in patients with random blood glucose of ≥7 mmol/l.[13] Whether hyperglycaemia upon presentation influences the outcome of NIV in acidotic COPD patients is not known nor is its relationship to other identified poor prognostic factors. To investigate these relationships we prospectively collected data about the occurrence of hyperglycaemia and the risk factors identified above in an observational study of consecutive patients with COPD undergoing NIV.

METHODS

Patients

All patients admitted to University Hospital Aintree between June 2006 and September 2007 with an exacerbation of COPD who received NIV within 24 h of admission to the Respiratory Failure Unit (RFU) or ICU were prospectively identified. AHRF was defined by the presence of worsening of dyspnoea and an arterial pH <7.35 with a $PaCO_2$ >6 kPa. The diagnosis of COPD was made clinically and confirmed by spirometry whenever possible.[14] Where spirometry was unavailable, a senior respiratory clinician confirmed that COPD was the most likely diagnosis based on the history, tobacco exposure, examination findings and radiology. An exacerbation of COPD was defined according to pre-existing criteria[14] while pneumonia was diagnosed when a new infiltrate on the chest radiograph occurred with one or more of the following: dyspnoea, cough, sputum production, fever >38°C, abnormal breath sounds and rales.[15] We excluded patients with other respiratory conditions—for example, chest wall and neuromuscular disease leading to acute on chronic ventilatory failure, those presenting with acute cardiogenic pulmonary oedema, those patients where doxapram was used as an adjunct to NIV, patients commenced on NIV >24 h following hospital admission and those with known active malignancy or a diagnosis of acute or chronic thromboembolic disease. In addition, patients with

COPD weaned using NIV postextubation and those unable to tolerate the mask due to agitation or claustrophobia were excluded. Details of the local protocol in our institution for administering NIV during acute exacerbations of COPD are given in the online supplement.

Protocol and measurements

Before initiating NIV, the RR was measured by a doctor, together with the arterial blood gases which were repeated at 1 and 4 h post-treatment. Details of the diagnosis, associated comorbidities, usual medication including oral corticosteroids, previous lung function and the time from presentation to the initiation of NIV were recorded together with body temperature, haemodynamic status and Glasgow Coma Score (GCS) pre-NIV. Venous blood was drawn for the measurement of the blood count (Sysmex XE-2100 automated full blood count analyser; Sysmex Milton Keynes, UK), routine biochemistry (AU 2700 automated chemistry analyser; Olympus UK, Watford, UK) and random glucose levels (hexokinase method, AU 2700 Olympus). In all episodes, blood samples were taken on admission to the Emergency Department but before NIV began—that is, the first blood glucose value that was obtained on hospital arrival was used. Hyperglycaemia was defined as a random blood glucose level $\geqslant$7 mmol/l.[13] The baseline APACHE II score was calculated by a single investigator (BC).[16] Preadmission comorbidity was assessed using the Charlson comorbidity index.[17] Successful NIV was defined as the resolution of respiratory acidosis leading to successful weaning from the ventilator, and no requirement for ventilatory support for at least a further 48 h. Formal ethical approval for the study was obtained via the regional ethics committee.

Statistical analysis

Statistical analysis was performed using SPSS 15.0. Data are presented as mean and SD unless otherwise stated. We used the independent sample t test to identify significant differences in continuous variables between patients failing or succeeding with NIV, and the χ^2 test for categorical variables. Statistical significance was defined as a p value <0.05. No "a priori" power calculation was performed as the relationship between blood glucose and NIV success in patients with COPD was not known. The statistical significance of each variable in predicting the outcome from NIV was initially determined using univariate logistic regression. Subsequently, baseline variables with a p value <0.1 were included in a multivariate logistic regression model which identified the most parsimonious predictors of NIV outcome. The variables identified from the logistic regression model were used to construct receiver operating characteristic (ROC) curves from which we determined the sensitivity, specificity, and positive and negative predictive value of these factors. Candidate variables were considered in isolation and in combination to establish whether they added additional explanatory power to this analysis.

RESULTS

Of 168 patients receiving NIV for decompensated AHRF, 109 episodes in 92 patients fulfilled the study entry criteria. Two patients were excluded due to claustrophobia and agitation during treatment, leaving 107 episodes in 90 patients (fig 1). Thirteen patients presented with more than one episode of AHRF during the study period comprising 17 such episodes in total. For those patients presenting with more than one episode of AHRF during the study period, the first episode was used for the purposes of the study, leaving 90 episodes in 90 patients. Random blood glucose data were available in 88 of these 90 patients, thus leaving 88 episodes in 88 patients for final analysis.

The ceiling of treatment was set at NIV alone in 73% (64/88) of patients. NIV failed in 16 patients (18%), one patient who received invasive ventilation surviving to discharge while the remaining 15 patients died, all of whom had NIV as their ceiling of treatment. In 11 (12%) patients, COPD exacerbation was associated with pneumonia but the mortality was not worse in this subgroup (p = 0.12). NIV was administered in the RFU in 86 patients and in the ICU for the remaining 2 patients.

The baseline demographics of the study population are outlined in table 1. Spirometry data confirming the diagnosis of COPD were available for 82 (93%) patients, all recordings being within a year of the index admission. Details of the six cases where COPD was diagnosed clinically are provided in the online supplement. In 16 patients (18%), oral corticosteroids were taken before admission. Intravenous aminophylline was administered in 24 patients and this did not affect the outcome of NIV (3 NIV failures received aminophylline p = 0.54; non-significant).

Glycaemia and outcome of NIV

The relationship between hyperglycaemia and outcome from NIV is summarised in table 2. Hyperglycaemia was present at baseline in 50% (44/88) of patients whilst 16 (18%) had a pre-existing diagnosis of diabetes mellitus. NIV failure was seen in 34% (15/44) of patients where random blood glucose was $\geqslant$7 mmol/l compared with 2% of the group with blood glucose $\leqslant$6.9 mmol/l (1/44; p = 0.003). The mean blood glucose level was higher in patients when NIV failed (9.03 (3.22) mmol/l vs 7.01 (2.18) mmol/l; t test; p = 0.003). A prior diagnosis of diabetes mellitus preadmission was not associated with failure of NIV (table 3), with the mean blood glucose in the 16 patients with diabetes being 8.03 (4.02) mmol/l compared with 7.23 (2.04) mmol/l in those without diabetes (p = 0.25 non-significant). Of the 44 patients with hyperglycaemia, pneumonia was noted in 7 (16%) compared with 4 patients (9%) with normoglycaemia (p = 0.52 non-significant).

When taking only those 82 patients where the diagnosis of COPD was confirmed by spirometry, the association between hyperglycaemia and failure of NIV remained. In this subgroup, NIV was successful in 71 patients and failed in 11. Baseline hyperglycaemia was present in 41% (29/71) of NIV successes and 100% (11/11) of NIV failures ($p<0.001$).

In 72 patients, oral corticosteroids were not taken before hospital admission and NIV succeeded in 58. In this subgroup,

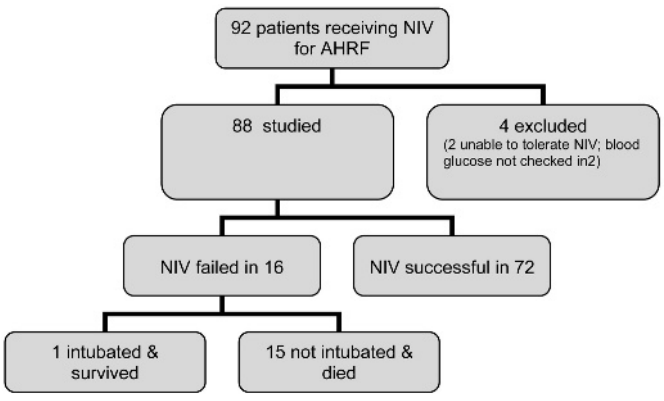

Figure 1 Flow diagram illustrating the outcome of patients receiving non-invasive ventilation (NIV) for acute hypercapnic respiratory failure (AHRF).

Table 1 Baseline demographics of the study population

Variable	Value
Age (years; mean (SD)), n = 88	70 (10)
Gender, n = 88	39 male (44%) 49 female (56%)
FEV_1 (litres; mean (SD)), n = 82	0.68 (0.29)
FVC (litres; mean (SD)), n = 82	1.62 (0.56)
Known diagnosis of diabetes mellitus	Yes = 16 (18%; 4 prescribed insulin) No = 72 (82%)
Glucose level prior to NIPPV initiation, n = 88	0–6.9 mmol/l = 44 (50%) >7 mmol/l = 44 (50%)
Arterial pH prior to NIPPV initiation, n = 88	7.25 (0.64)
Arterial pCO_2 prior to NIPPV initiation (kPa), n = 88	10.20 (2.17)
Arterial pO_2 prior to NIPPV initiation (kPa), n = 88	8.19 (2.65)
Calculated bicarbonate (mmol/l), n = 88	25.65 (3.60)
Respiratory rate prior to NIPPV initiation (breaths/min), n = 88	27 (8)
APACHE II score prior to NIPPV initiation, n = 88	15 (4)
Charlson comorbidity index, n = 88	1.66 (0.76)

Values are given as mean (SD).
APACHE II, Acute Physiology and Chronic Health Evaluation II; FEV_1, forced expiratory volume in 1 s; FVC, forced vital capacity; NIPPV, non-invasive positive pressure ventilation.

baseline hyperglycaemia was present in 38% (22/58) of NIV successes and 93% (13/14) of NIV failures ($p<0.001$). Hyperglycaemia was not related to prior oral corticosteroid use. Of the 16 patients prescribed oral corticosteroids preadmission, 9 (56%) presented with hyperglycaemia compared with 35 of 72 (49%) not prescribed oral corticosteroids ($p = 0.59$; non-significant).

Arterial blood gases and outcome of NIV

The relationships between the baseline pH, subsequent change in arterial blood gases over 4 h and outcome of NIV are shown in table 4 and in table 1 online. A baseline pH <7.30 before NIV did not predict NIV failure, although the relationship between outcome and presentation with a baseline pH <7.25 approached statistical significance ($p = 0.09$). In 84 patients, NIV was still being used 4 h after initiation (4 patients had died by this stage). Failure to improve arterial pH compared with baseline after 4 h NIV treatment was not associated with treatment failure nor was the inability to normalise pH following 4 h of NIV predictive.

Logistic regression analysis

Of the baseline variables tested, age, blood glucose <7 mmol/l, baseline RR, APACHE II score, mean baseline arterial pH pre-NIV and calculated serum bicarbonate level were related to the outcome of NIV treatment in the univariate logistic regression (see tables 3, 4). These variables were included in the multivariate model which identified three statistically significant predictors of NIV outcome: baseline RR (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 APACHE II score on admission (OR 0.75; 95% CI 0.62 to 0.90). The model correctly classified 93% of the successful outcomes in the sample.

The correlation between random blood glucose and the other statistically significant associations identifying NIV outcome in the univariate analysis are shown in tables 2 and 3 online. Statistically significant correlations were noted between blood glucose concentration, RR and pre-NIV pH in those patients where NIV was successful, and with baseline APACHE II score and pre-NIV pH where NIV failed. The correlations between baseline RR and APACHE II index and with pre-NIV pH were 0.25 ($p = 0.01$) and −0.16 ($p = 0.14$, non-significant), respectively, in the whole cohort.

Table 2 Relationship between glycaemia and outcome from NIV

Random blood glucose quartile (mmol/l)	NIV success (no. of cases)	NIV failure (no. of cases)
0–6 (n = 28)	27 (96%)	1 (4%)
6–6.9 (n = 16)	16 (100%)	0 (0%)
7–8.9 (n = 26)	17 (65%)	9 (35%)
>9 (n = 18)	12 (67%)	6 (33%)

NIV, non-invasive ventilation.

To investigate further the discriminatory power of the three variables, ROC curves were constructed between RR, APACHE II index, blood glucose level and the outcome of NIV. For baseline RR and NIV outcome, the lines for sensitivity and specificity intersected at an RR of 30/min (area under the curve 0.78; 95% CI 0.62 to 0.94). In terms of APACHE II index, the point of intersection occurred at 16.5 (area under the curve 0.79; 95% CI 0.66 to 0.91), and with random blood glucose level (area under the curve 0.76; 95% CI 0.63 to 0.89) the point of intersection was at 7.3 mmol/l. The sensitivity, specificity, and positive and negative predictive value of these factors in predicting a successful outcome is shown in table 4 online. The combination of baseline RR <30 breaths/min and random glucose <7 mmol/l increased the prediction of a successful outcome from NIV to 97%, while the use of all three factors was 100% predictive in this population.

DISCUSSION

NIV represents a significant advance in the management of acute respiratory failure in patients with severe COPD. The data in our observational prospective cohort study support this, with >80% of patients recovering from an episode which a decade ago would have required invasive ventilation. This success rate is comparable with that previously reported from an ICU[18] and was not substantially different from a more mixed population of patients, many without acidosis, admitted to UK hospitals.[19] Patients with COPD managed with invasive ventilatory support are more likely to die from non-pulmonary causes than respiratory causes.[20] In surgical and medical intensive care practice hyperglycaemia is a known adverse prognostic marker.[7 21 22] Specific data about hyperglycaemic patients managed with NIV are limited. A small study suggested that "late failure" defined by deteriorating gas exchange was more frequent in patients with an initially raised blood sugar.[3] A larger but retrospective review of a mixed population of unselected patients with COPD noted longer hospital stays and greater mortality in patients presenting with hyperglycaemia. However, it was not possible to adjust for the potential confounding effects of corticosteroids while many of the diagnoses were based on purely clinical grounds.[13]

Our study in a well defined patient population found that hyperglycaemia, even when defined at only one time point, related to the final outcome irrespective of the diagnosis of diabetes, use of insulin or prior oral corticosteroid use. In general the degree of hyperglycaemia observed was modest but it may still reflect the significant physiological stress associated with deteriorating gas exchange and worsening lung mechanics, often accompanied by pulmonary infection. Some patients had radiological evidence of pneumonia, but this did not explain the occurrence of hyperglycaemia in most patients nor did it predict

Table 3 Clinical variables and outcome from NIV: univariate analysis

	NIV success (n = 72)	NIV failure (n = 16)	OR (95% CI)	p Value
Age, n = 88*	68 (10)	77 (9)	0.9 (0.84 to 0.97)	0.006
Gender, n = 88†	M = 34	M = 5	1.97 (0.62 to 1.97)	0.25 (NS)
	F = 38	F = 11		
Smoking status, n = 88†	Ex = 37	Ex = 10	0.57 (0.19 to 1.72)	0.32 (NS)
	Current = 35	Current = 6		
FEV_1 (litres), n = 82*	0.69 (0.30)	0.60 (0.17)	4.53 (0.19 to 106.4)	0.35 (NS)
FVC (litres), n = 82*	1.67 (0.55)	1.35 (0.48)	3.64 (0.73 to 18.07)	0.11 (NS)
Diagnosis of diabetes mellitus, n = 16†	12	4	0.6 (0.17 to 2.18)	0.44 (NS)
Glucose ⩾7 mmol/l, n = 88†	Glucose ⩾7 mmol/l = 29	Glucose ⩾7 mmol/l = 15	0.05 (0.006 to 0.36)	0.003
	Glucose <7 mmol/l = 43	Glucose <7 mmol/l = 1		
Time from admission to NIV administration (h), n = 88*	4.68 (4.76)	3.59 (3.85)	1.07 (0.92 to 1.24)	0.40 (NS)
IPAP (cm H_2O), n = 88*	15.07 (2.17)	15.00 (3.29)	1.01 (0.80 to 1.28)	0.34 (NS)
EPAP (cm H_2O), n = 88*	5.24 (1.38)	5.63 (1.78)	0.84 (0.58 to 1.2)	0.16 (NS)
APACHE II, n = 88*	14.63 (3.80)	19.19 (4.31)	0.76 (0.65 to 0.89)	0.001
Oral corticosteroid administered prior to admission, n = 16†	14 (19%)	2 (13%)	1.69 (0.34 to 8.31)	0.52 (NS)
Charlson comorbidity index, n = 88*	1.62 (0.73)	1.88 (0.93)	0.78 (0.35 to 1.25)	0.20 (NS)
GCS, n = 88*	14 (1)	13 (3)	1.21 (0.93 to 1.45)	0.18 (NS)
Pneumonia cases, n = 11†	7	4	0.32 (0.08 to 1.28)	0.12 (NS)
Baseline RR (breaths/min), n = 88*	26 (6)	34 (10)	0.86 (0.79 to 0.94)	0.001

Values are given as mean (SD).
*t test.
†χ^2 test.
APACHE II, Acute Physiology and Chronic Health Evaluation II; EPAP, expiratory positive airway pressure; F, female; FEV_1, forced expiratory volume in 1 s; FVC, forced vital capacity; GCS, Glasgow Coma Score; IPAP, inspiratory positive airway pressure; M, male; NIV, non-invasive ventilation; NS, non-significant; RR, respiratory rate;

NIV failure. Thus, in our data initial hyperglycaemia had an independent prognostic value.

Initial observational data suggested a relationship between the severity of acidosis and the outcome of AHRF in COPD, a finding supported by subsequent randomised studies.[2 23] Our mean baseline pH was <7.25 in 42% of patients but, unlike the earlier studies, treatment succeeded in >70% of cases. This may explain why baseline pH was a poorer discriminant in the patient population now referred for NIV. In contrast, the initial respiratory rate was a good measure of treatment response, as has been seen elsewhere.[1 2 5 24 25] A higher RR may reflect asynchrony of the patient and the ventilator, but it may also be a marker of a greater intrinsic respiratory load promoting a shortened inspiratory time and more hypercapnia.[26 27] As the respiratory muscles are unloaded by the effects of NIV, the RR can fall, the associated pulmonary hyperinflation lessens along with the work of breathing and dyspnoea improves.[27] We observed a relationship between the APACHE II score and clinical outcomes, which was unsurprising as this index incorporates several variables which independently predicted outcome. However, the APACHE II score was no better in predicting outcome in our data than simpler measures such as the initial RR.

Table 4 Outcome from NIV and relationship with arterial blood gas variables: univariate analysis

	NIV success (n = 72)	NIV failure (n = 16)	OR (95% CI)	p Value
Baseline pH, n = 88*	7.26 (0.06)	7.22 (0.08)	3.96 (1.55 to 5.07)	0.02
Baseline PaO_2 (kPa), n = 88*	8.15 (2.73)	8.30 (2.31)	0.98 (0.80 to 1.20)	0.87 (NS)
Baseline $PaCO_2$ (kPa), n = 88*	10.20 (2.19)	10.20 (2.16)	0.99 (0.78 to 1.28)	0.99 (NS)
Baseline calculated bicarbonate (mmol/l), n = 88*	26.09 (3.44)	23.51 (3.69)	1.24 (1.04 to 1.45)	0.014
1 h pH, n = 88*	7.29 (0.06)	7.25 (0.09)	1.78 (0.04 to 2.23)	0.03
1 h $PaCO_2$ (kPa), n = 88*	8.84 (2.21)	9.50 (2.61)	0.88 (0.68 to 1.15)	0.36 (NS)
1 h PaO_2 (kPa), n = 88*	8.77 (2.87)	7.85 (1.64)	1.27 (0.84 to 1.91)	0.26 (NS)
4 h pH, n = 84*	7.32 (0.51)	7.28 (0.90)	4.34 (2.90 to 5.89)	0.14 (NS)
4 h PaO_2 (kPa), n = 84*	8.37 (2.39)	7.70 (1.22)	1.27 (0.79 to 1.96)	0.31 (NS)
4 h $PaCO_2$ (kPa), n = 84 *	8.19 (1.98)	8.47 (2.07)	0.93 (0.68 to 1.27)	0.66 (NS)

Values are given as mean (SD).
*t test.
NIV, non-invasive ventilation; NS, non-significant.

Multivariate logistic regression analysis identified three factors which explained almost all the variance in outcome in our patient group and which were largely independent of each other. ROC curve analysis defined threshold values in this population, which agreed with the conventional level of elevated blood glucose in the case of hyperglycaemia and which independently identified an RR of 30/min, the same value used in the highly discriminant CURB65 score for pneumonia severity.[28] The relative simplicity with which these variables can be measured suggests that a simple prognostic index can be developed based on these factors if our findings are validated in other trials. The presence of RR <30 combined with normoglycaemia prior to the initiation of NIV carried a specificity of 92% in predicting success from NIV with a sensitivity of 79%. When baseline RR <30 was combined with normoglycaemia and APACHE II index ⩽16, the specificity increased to 100%. In essence, the combination of these "favourable" criteria in a patient with COPD with decompensated ventilatory failure prior to initiation of NIV predicts a successful outcome. On the other hand, in terms of predicting failure of NIV, the presence of an RR ⩾30/min coupled with hyperglycaemia carried a negative predictive value of 97% and a sensitivity of 92% (the failure rate was 55% in this subgroup). We therefore conclude that the presence of these "unfavourable" criteria in a patient at baseline does not imply NIV will definitely fail but such patients may require more intensive and aggressive monitoring as there is a significantly higher risk of treatment failure in such circumstances. Validation of this model in terms of predicting outcome from NIV in acute decompensated ventilatory failure is required in a second cohort of patients.

Our study has some limitations. Although it was a prospective study, we recorded only one blood glucose value and this may vary during an acute illness. However, the use of a threshold value close to the upper limit of normal had significant discriminatory power when used as a binary outcome for NIV success. Furthermore, the timing of the measurement was similar in all cases—that is, upon presentation to hospital but prior to NIV initiation. In addition, the overall sample size of the study was small but did comprise a relatively homogenous population. We had limited information about the role of infection in these patients, but again the predictive variables selected are indirectly linked to the consequences of infection. In our cohort, acute NIV carried a relatively low failure rate of 18%. This may reflect the patient selection criteria used—that is, only patients with COPD receiving NIV within 24 h of hospital admission were included. Patients developing decompensated ventilatory failure after a longer hospitalisation or when complicated by a hospital-acquired infection probably represent a sicker group carrying a higher failure rate. Our failure to identify an association with baseline pH may reflect this focused entry criterion, although the absolute values are rather lower than in several other series. The high mortality in patients who failed NIV may reflect both the severity of the initial presentation and also current UK practice towards additional supportive ventilation which continues to be a topic for debate.[29] Our data relate to the first episode on an admission when the patient was ventilated and to the outcome of that episode. One individual who recovered from such an episode subsequently died before discharge, but overall our mortality is in keeping with other recent reports in the literature.[6 30] Although not all patients had spirometrically confirmed COPD, the predictive value of hyperglycaemia remained even after excluding those cases where spirometry was not performed. Certain factors known to affect tolerance to NIV were not measured, such as the degree of mask leak, the presence of secretions and the ability to remove them. Further research in these important areas is needed.

In summary, when patients with COPD develop decompensated ventilatory failure, baseline hyperglycaemia identifies patients with the greatest risk of failure with NIV, as does an elevated RR and increased APACHE II index on admission. Combining these approaches should provide a relatively simple way of stratifying risk and adjusting management accordingly. The RR remains an underused measurement which tracks the patient's progress. Whether changes in blood glucose during therapy are as helpful remains to be studied. Tight glycaemic control has its advocates,[11 12] but careful prospective studies will be needed before this approach can be recommended in the care of patients with primary respiratory problems treated with NIV.

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Pulmonary puzzle

Cough, confusion and flaccid paralysis in a 46-year old man with left apical consolidation and ring-enhancing lesions on cerebral imaging

CLINICAL PRESENTATION

A 46-year-old man was admitted with confusion and lower limb weakness that had developed over 2 weeks. A history of chronic productive cough was noted. Significantly, 4 years previously he had been investigated for cough and left apical lung consolidation. No evidence of *Mycobacterium tuberculosis* was found at the time and this was not investigated further. The only other relevant history was of heavy ethanol intake and self-neglect.

The patient was febrile (38.6°C), confused and unwell. He had evidence of finger clubbing, poor oral hygiene and signs of consolidation in the left lung. Early bilateral papilloedema and a flaccid paralysis in the lower limbs were noted. Admission investigations identified a raised white cell count of 21.5×10^9/l (neutrophils 19.5). Multiple sputum cultures were negative. There was no reaction to a Mantoux (5 units PPD) test. Antibodies to HIV were not detected. A chest radiograph (fig 1) and CT scan showed left apical consolidation and volume loss. A CT scan of the brain (fig 2) showed two ring-enhancing lesions in the right frontoparietal lobe. An MRI scan revealed a ring-enhancing lesion in the lumbar spine.

Craniotomy and excision of a cerebral lesion was performed, with concurrent bronchoscopy and bronchoalveolar lavage (BAL). The airways were inflamed with inspissated yellow secretions visible on the left. Histological examination of the cerebral biopsy specimen was consistent with a cerebral abscess, but no granulomatous inflammation was identified. All cultures from the BAL fluid and cerebral abscess were negative.

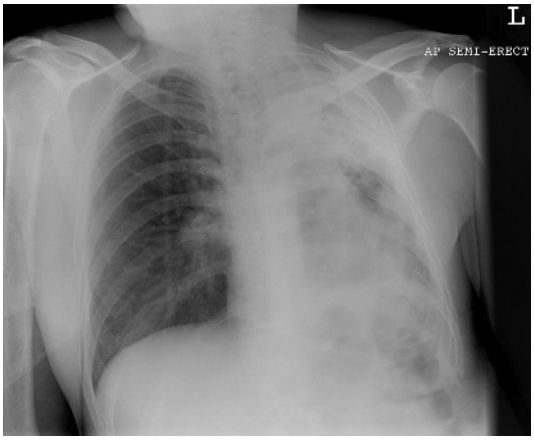

Figure 1 Chest radiograph showing left apical consolidation, volume loss and pleural thickening.

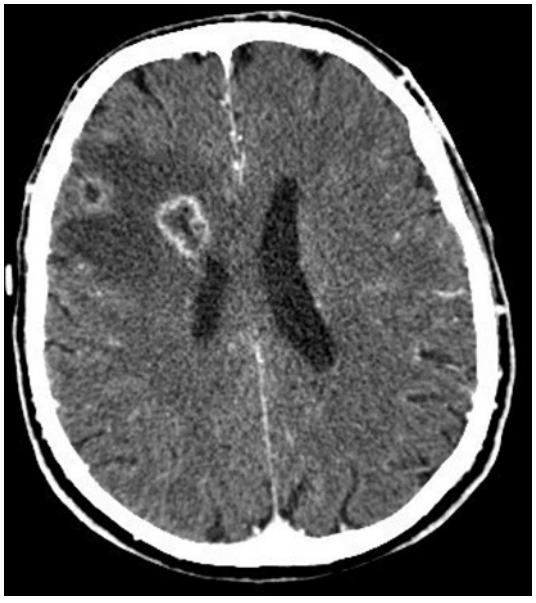

Figure 2 CT scan of the brain showing ring-enhancing lesions in the right frontoparietal lobe with surrounding oedema and mass effect.

QUESTION

What further diagnostic technique may aid in pathogen identification?

See page 920.

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