Online data supplement

METHODS

Sniff manoeuvre

The sniff manoeuvre was selected in preference to the maximal inspiratory pressure or inspiratory capacity manoeuvres, as it is manageable for patients to perform when they are acutely unwell with coryzal symptoms accompanying an acute exacerbation [1 2]. Patients were requested to perform “a short, sharp sniff in, as hard as you can” on at least three occasions, until two values were obtained within 10% of each other.

RESULTS

Recruitment and data collection

Enrolment data for this detailed physiological observational cohort study are shown in Figure E1. 597 EMG_{para} measurements were made in 122 patients over 521 inpatient days, yielding 475 pairs of consecutive data. For the analysis of inpatient clinical deterioration, 88% of consecutive measurements were made at an interval of 1 day or less; 8% were made at an interval of 2 days and 4% were made at an interval of 4 days or more. All 120 patients included in the admission-to-discharge analysis for readmission risk had EMG_{para} measurements on the day of admission and the day of fitness for discharge.

Prediction of respiratory admissions and acute healthcare utilisation within 14 and 28 days

Respiratory admissions

There were 14 (11.7%) respiratory admissions within 14 days and 25 (20.8%) respiratory admissions within 28 days of hospital discharge. As with all-cause readmissions, higher positive values of $\Delta EMG_{para\%max}$ were associated with increased risk of 14-day respiratory readmission (OR 1.13 95% CI 1.04 to 1.23). In patients under 85, increased admission frequency (OR 1.48, 95% CI 1.11 to 1.98) and higher $\Delta EMG_{para\%max}$ (OR 1.10, 95% CI 1.01 to 1.20) were associated with increased risk of 28-day respiratory readmission.

Acute healthcare utilisation

There were 18 (15%) episodes of acute healthcare utilisation within 14 days and 29 (24.2%) episodes of acute healthcare utilisation within 28 days of hospital discharge. These included hospital admissions and attendances to the emergency department that did not require admission. A greater change in $EMG_{para\%max}$ was associated with an increased risk of 14-day acute healthcare utilisation (OR 1.11, 95% CI 1.03 to 1.20). In patients under 85, increased age (OR 1.08, 95% CI 1.009 to 1.146), increased admission frequency (OR 1.38, 95% CI 1.03 to 1.84) and greater values of $\Delta EMG_{para\%max}$ (OR 1.09, 95% CI 1.002 to 1.175) were associated with 28-day acute healthcare utilisation.

Dynamic hyperinflation and neural respiratory drive

A correlation was noted between admission-to-discharge changes in IC and changes in $EMG_{para\%max}$ (Figure 2C). Patients whose IC increased between admission and discharge demonstrated a fall in NRD ($\Delta EMG_{para\%max}$ -3.2±7.2%), whilst those whose IC decreased demonstrated an increase in NRD ($\Delta EMG_{para\%max}$ +1.1±5.4%). This difference between the two groups was significant (p=0.005). However, there were no differences in readmission rate at either 14 or 28 days between patients whose IC increased and decreased during hospital admission.

Patients without radiographic consolidation

20.8% of patients had radiographic consolidation on chest X-Ray at admission. There were no differences between readmitted and non-readmitted groups, either at 14 or 28 days, in terms of the proportion of patients with radiographic consolidation. When patients with radiographic consolidation were excluded, 28-day readmission was associated with age alone (OR 1.082, p=0.004) in the whole cohort, and age (OR 1.074, p=0.049) and ΔEMGpara%max (OR 1.112, p=0.019) in patients under the age of 85 years. 14-day readmission was associated with $\Delta EMG_{para\%max}$ alone (OR 1.124, p=0.006).

DISCUSSION

Critique of the method

Frequency of data acquisition

The study protocol stipulated that daily EMG measurements were undertaken at a similar time each day, but this was, on occasions, impossible due to either the patient or research team being unavailable, or patient refusal. However, the majority of measurements were obtained on consecutive days in these acutely unwell patients. Despite the large number of patients included, this study was conducted in a single centre university hospital with an established and extensive experience of respiratory muscle measurements.

Changes in sniff EMG between admission and discharge

The value of parasternal EMG during tidal breathing was normalised against the maximum parasternal EMG value obtained during a maximal sniff manoeuvre. Although, as expected, there was variation in the maximum values within the cohort between admission and discharge (*Fig. E2*), the research team gave significant attention to the technical set up and application of the EMG_{para} measurement. In particular, the skin was marked so that the electrode position was the same on each day of EMG_{para} measurement and therefore we do not consider technical acquisition of the signal to be a contributing factor. Indeed, we consider that $EMG_{para\%max}$ using daily measurements of maximum sniff EMG_{para} to be an appropriate method. However, we acknowledge that the variation in sniff EMG would, in part, be as a consequence of variations in effort as the clinical condition and ability of the patient to perform this volitional test changes. Having said that, we observed that there was no difference between the sniff EMG_{para} between the readmitted and non-readmitted groups. Furthermore, when the EMG values were normalised to the maximum value of parasternal EMG obtained at the time of discharge (i.e. when the patients were at their most stable; $EMG_{para\%max@discharge}$), the ability of EMG_{para} to predict clinical outcomes was preserved. An increase in $EMG_{para\%max@discharge}$ (adjusted OR 1.09, 95% CI 1.01 to 1.19) between admission and discharge was associated with increased risk of 28-day readmission in patients under 85 (n=112). In the whole cohort, a rise in $EMG_{para\%max@discharge}$ was associated with increased risk of 14-day readmission (OR 1.10, 95% CI 1.02 to 1.20). Increases in $EMG_{para\%max@discharge}$ also predicted 14-day respiratory readmissions (OR 1.12, 95% CI 1.02 to 1.22) and 14-day acute healthcare utilisation (OR 1.10, 95% CI 1.02 to 1.19).

When the tidal breathing EMG_{para} values at discharge were expressed as a ratio of the values at admission ($EMG_{para,discharge}/EMG_{para,admission}$), the ability of EMG_{para} to predict 14-day respiratory readmissions was still preserved ($\Delta EMG_{para,discharge}/EMG_{para,admission}$: OR 3.69, 95% CI 1.02 to 13.36). Even without normalising against a maximal value of EMG, the change in raw EMG_{para} values from admission to discharge was able to predict the clinically important outcome of respiratory readmission; however, this parameter was unable to predict 14- or 28-day all-cause readmission, which is currently of major importance for UK and US acute healthcare organisations.

Clinical applicability of the findings

Relationship between dyspnoea and NRD

Previous studies in patients with chronic respiratory disease during exercise have shown a close relationship between levels of dyspnoea and NRD [1 3 4]. In the current study, although EMG_{para} was able to detect worsening breathlessness between consecutive measurements, there was no correlation between admission-to-discharge change in perceived breathlessness and change in $EMG_{para\%max}$. This observation highlights the limitation of the laboratory model of breathlessness and the acute condition. Specifically, the incremental increase in dyspnoea in stable patients undergoing a standardised exercise test differs from the variation in dyspnoea in acutely unwell patients over the treatment course of an exacerbation. In addition, the course of a hospital admission is over days, whereas patients undergoing a short, clearly defined exercise test have a clear perception of their breathlessness, which can be referenced to their resting state at each point of the exercise protocol.

Fig. E1 Flow diagram for screening and enrolment of COPD patients

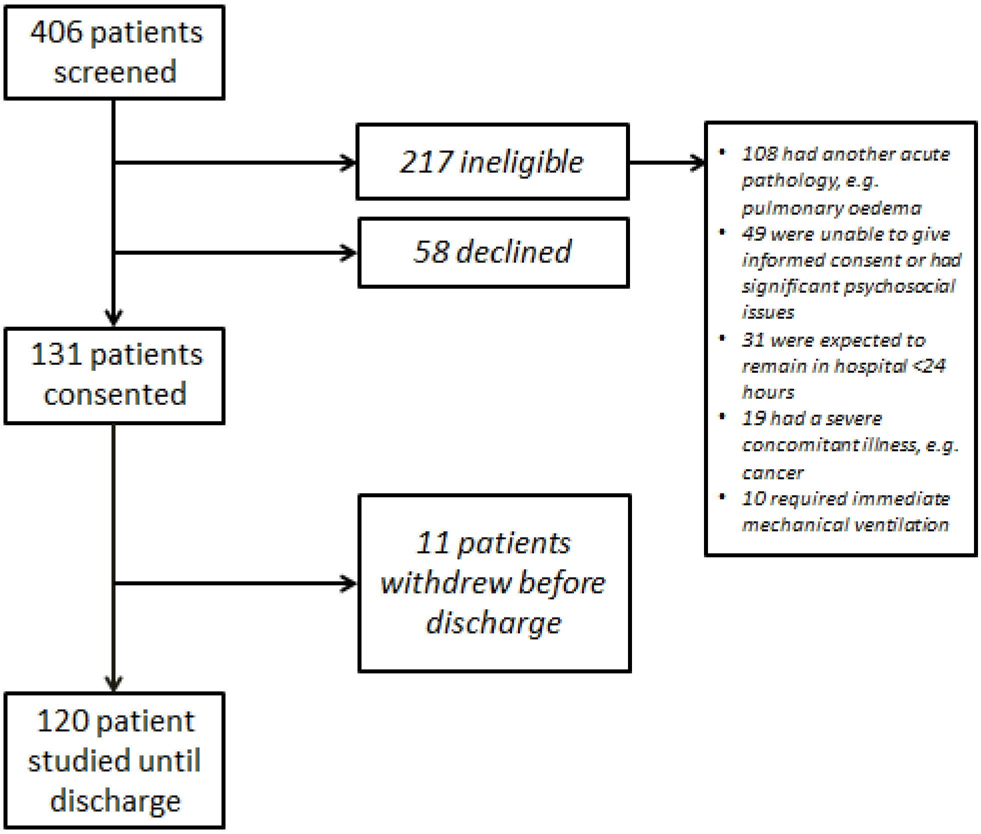
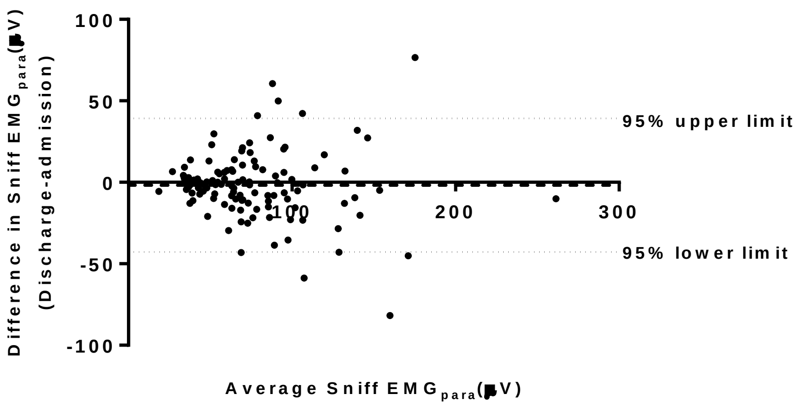


Figure E2. Bland-Altman plot showing variation in sniff EMG measurements between hospital admission and discharge



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