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ORIGINAL RESEARCH

Controlled oxygen therapy at emergency department presentation increases the likelihood of achieving target oxygen saturations in patients with exacerbations of chronic obstructive pulmonary disease

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Abstract

***Objective*:** This study aimed to determine whether initiation of controlled oxygen therapy at ED presentation increased the proportion of patients with chronic obstructive pulmonary disease (COPD) achieving the COPD-X guideline target SpO_2 range (88–92%) at 30 min and if it impacted total hospital length of stay or in-hospital mortality.

***Methods*:** Retrospective cohort study by medical record review of patients admitted to hospital with an exacerbation of COPD. The primary outcome of interest was the proportion of patients achieving the target SpO_2 range at 30 min after ED arrival.

***Results*:** The proportion of patients with SpO_2 in the target range at 30 min was higher in the controlled oxygen therapy group (32% *vs* 16%: difference between proportions 16% (95% CI 7–24%); number needed to treat 6) and less likely to be over-oxygenated ($SpO_2 > 95\%$), 29% versus 54%, difference between proportions 25% (95% CI 14–35%); number needed to harm 4, without an increased likelihood of hypoxia. Length of stay was not different between the groups. Mortality for the controlled oxygen group was 2.7% (95% CI 1.3–5.5%) versus 5.8% for the uncontrolled oxygen group (95% CI 2.9–11.6%); however, this trend was not statistically significant.

***Conclusion*:** Patients with exacerbations of COPD receiving controlled oxygen therapy were more likely to achieve SpO_2 within the COPD-X guideline target range without being more likely to be hypoxic. The proportion of patients with SpO_2 within the target range was low, suggesting that further work on processes to optimise oxygenation in this group of patients is needed.

Key words: *COPD, mortality, oxygen.*

Key findings

- Patients with exacerbations of COPD receiving controlled oxygen therapy were more likely to achieve SpO_2 within COPD-X target range.
- They were not more likely to be hypoxic or over-oxygenated.
- The proportion of patients with SpO_2 in the COPD-X target range was low.

Introduction

The Australian COPD-X guidelines (2015)[1] recommend that for patients with exacerbations of chronic obstructive pulmonary disease (COPD) treated in emergency settings oxygen flow should be carefully titrated to achieve oxygen saturations (SpO_2) between 88% and 92%. This is usually achieved by using nasal prongs with oxygen flows at appropriate rates or venturi-type oxygen delivery systems. The rationale for this recommendation is that there is evidence that high flow oxygen administered in the prehospital setting may increase mortality (number needed to harm 14)[2] and that uncontrolled oxygen therapy is associated with an increased risk of death, assisted ventilation or respiratory failure in patients presenting to hospital.[3]

We aimed to determine whether initiation of controlled oxygen therapy at ED presentation increased the proportion of patients achieving the target SpO_2 range at 30 min and if it impacted total hospital length of stay or in-hospital mortality.

Methods

Design and setting

This was an unplanned sub-study of a retrospective cohort study conducted by medical record review of patients presenting to ED with a final hospital diagnosis of COPD. The parent study aimed to compare mortality for those receiving controlled versus uncontrolled oxygen therapy. It was conducted at two university-affiliated metropolitan teaching hospital EDs with a combined annual ED census of approximately 105 000.

Patient selection

Inclusion criteria were age ≥18 years and ED discharge diagnosis of COPD.

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We excluded patients who did not receive oxygen therapy after initial ED assessment, failed to have COPD confirmed as the principal hospital discharge diagnosis, who were discharged home from ED (presumed mild disease), who were receiving assisted ventilation on ED arrival or required non-invasive ventilation (NIV) initiated on ED arrival and missing or unavailable records.

Patients were identified from the ED data management system for the period 1 January 2012 to 31 March 2013. There were 864 potentially eligible patients. A convenience sample of 642 patients, based on record accessibility during the study timeframe, was screened for inclusion representing approximately 74% of all potentially eligible patients. Patients were eligible for inclusion more than once.

During the period covered by the study, nurses were free to choose whatever form of oxygen delivery mode they thought most suitable. In particular, they were not required to continue the same mode of delivery that was used in the prehospital setting. About a year before this study, an educational campaign had been undertaken in one of the study EDs regarding the use of controlled oxygen therapy in patients with known or suspected COPD as part of a quality improvement project and, since then, it has been included in nursing orientation programmes. Following the campaign, audit data showed that rates of controlled oxygen delivery use were approximately 60%. As this study was retrospective, nurses were unaware that it was being conducted at the time of the relevant clinical encounters. It should also be noted that at the study institution, nebulised bronchodilators are routinely oxygen driven; there is very limited availability of medical air for this purpose.

Data collection, definitions and outcomes of interest

Data was collected onto a standard, piloted data collection form (Appendix S1). Data collected included demographics, use of home oxygen, primary hospital discharge diagnosis, oxygen delivery mode initiated at ED arrival, SpO_2 at 30 min after ED arrival, hospital length of stay and in-hospital mortality. Data was collected by clinicians who were not blinded to the parent study objective. As this was an unplanned sub-study, they were unaware of the objective of this sub-study. Data collectors were trained in data definitions and use of the data form.

The primary outcome of interest was the proportion of patients achieving the COPD-X target SpO_2 range (88–92%) at 30 min after ED arrival. Secondary outcomes of interest were length of stay and in-hospital mortality by initial oxygen delivery mode (controlled *vs* uncontrolled). The controlled oxygen therapy group was defined as use of nasal prongs or venturi-type system. Uncontrolled was defined as face-mask (any other type) or unknown.

Inter-rater agreement was assessed for 63 patients (17%) for the items SpO_2 at 30 min within COPD-X target range and in-hospital mortality.

Data analysis and sample size

Analysis is descriptive with 95% confidence intervals. Chi square or Fisher's exact tests (where appropriate) were used to test differences between proportions. Continuous data is reported as medians with inter-quartile range and compared using Mann–Whitney *U*-test. A *P*-value <0.05 was considered statistically significant and tests were two-sided. Inter-rater agreement was performed using the Kappa test. Analysis was performed using Analyse-It® software (www.analyse-it.com).

Regarding sample size, to show a difference of 20% in achieving the target SpO_2 (30% *vs* 50%) with power of 0.8, alpha of 0.05 would require approximately 75 patients per group. As we were aware that approximately 40% of patients would probably receive uncontrolled oxygen therapy (based on previous audit data), the target sample size was set at least 100 eligible patients per group.

Ethics approval

Ethics approval as a quality assurance project was obtained from the Western Health Low Risk Ethics Panel. Patient consent was not required.

Results

A total of 378 patients met the inclusion and exclusion criteria (Fig. 1). Median age was 73 years (IQR 64–79) and 53% were male. Controlled oxygen therapy was used in 68% of patients ($n = 258$, nasal prongs 38%, venturi-type system 30%) while uncontrolled oxygen therapy was used in 32% ($n = 120$, face masks, e.g. Hudson™ mask and non-rebreather 26%, 6% unknown mode of delivery). Characteristics of the overall sample and comparison groups are shown in Table 1.

The proportion of patients with SpO_2 in the target range at 30 min after ED arrival was 32% in the controlled oxygen delivery group (82/258; 95% CI 25–38%) versus 16% in the uncontrolled group (19/

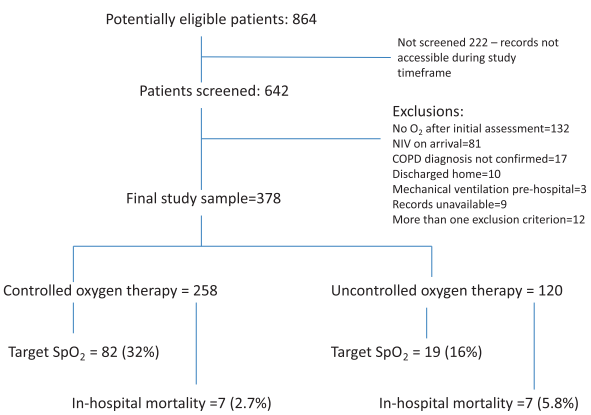

Figure 1. *Sample derivation. COPD, chronic obstructive pulmonary disease; O_2, oxygen; NIV, non-invasion ventilation; SpO_2, oxygen saturation.*

TABLE 1. *Comparison of controlled versus uncontrolled oxygen groups*

Parameter	Overall ($n = 378$)	Controlled oxygen cohort ($n = 258$)	Uncontrolled oxygen cohort ($n = 120$)	*P*-value for comparison
Age, median, IQR	73, 64–79	73, 65–79	72, 62–78	0.09
Gender, number male, %	202, 53%	134, 52%	68, 57%	0.39
Home oxygen, number, %	100, 27%	82, 32%	18, 15%	0.0006
Arrival by ambulance, number,%	310, 82%	216, 84%	94, 78%	0.20
Length of stay, median, IQR	5.0, 4–8	5.0, 4–8	5.0, 3–7	0.17
In-hospital mortality, number, %	14, 3.7%	7, 2.7%	7, 5.8%	0.23

120; 10–23%); difference between proportion 16% (95% CI 7–24%); number needed to treat 6. Patients not receiving controlled oxygen therapy were more likely to be over-oxygenated ($SpO_2 > 95\%$), 54% (65/120) versus 29% (75/258); difference between proportions 25% (95% CI 14–35%); number needed to harm 4. Patients receiving controlled oxygen therapy were not more likely to be hypoxic ($SpO_2 < 88\%$) at 30 min (7% *vs* 6%; $P = 0.82$). The proportion of patients in each SpO_2 range at 30 min is shown in Figure 2. The proportion achieving the target range did not differ between the venturi system and the nasal prongs subgroups (31% *vs* 33%; difference between proportions 2%, 95% CI −9% to 14%) nor did the proportion of patients with $SpO_2 > 95\%$ (27% *vs* 31%, difference between proportions 4%, 95% CI −7% to 15%).

Length of stay was not different between the groups (median 5.0 days for each, Table 1). Overall in-hospital mortality was 3.7% (14/378; 95% CI 2.2–6.1%). Mortality for the controlled oxygen group was 2.7% (7/258; 95% CI 1.3–5.5%) versus 5.8% for the uncontrolled oxygen group (7/120; 95% CI 2.9–11.6%); however, this trend was not statistically significant ($P = 0.23$).

Inter-rater agreement for oxygen saturation within COPD-X target range at 30 min had a kappa value of 0.92 (percent agreement 97%). Agreement for in-hospital mortality classification was 98% (kappa 0.85).

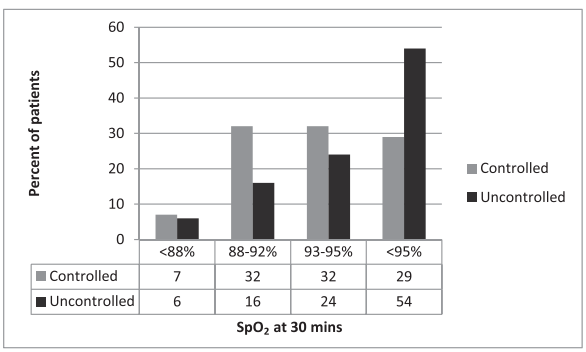

Figure 2. *Proportion of patients in each SpO_2 range at 30 min.*

Discussion

Our results show that patients with exacerbations of COPD receiving controlled oxygen therapy were more likely to achieve SpO_2 within the COPD-X[1] target range of 88–92% and less likely to be over-oxygenated ($SpO_2 > 95\%$) compared with the uncontrolled oxygen group, without being more likely to be hypoxic. That said, the proportion of patients with SpO_2 within the target range was considerably lower than was expected, suggesting that further work on process improvements to optimise oxygen delivery for this group of patients is needed.

While there is conjecture about what SpO_2 level represents clinically significant over-oxygenation for patients with COPD,[4] a significant proportion of patients had SpO_2 at 30 min >95%, and this proportion was significantly higher in the uncontrolled oxygen group. We did not collect data on reasons for choice of oxygen delivery mode or reasons for over-oxygenation. However, possible explanations include lack of awareness of the COPD-X guideline target, lack of recognition of the risks associated with over-oxygenation particularly in patients not on home oxygen and lack of respect for oxygen as a drug.

Changing clinical practice is not easy. There is evidence that over-oxygenation is an entrenched practice among health professionals[2,4] despite the availability of guidelines for some years.[5] Approaches to change practice include education, the use of management pathways for respiratory conditions and the recently suggested requirement for oxygen therapy to be prescribed similar to a drug.[6]

The in-hospital mortality rate in our study was towards the lower end of rates reported in the literature, which range from 2% to 7.7% (median approximately 5%).[7–13] There was a trend towards lower mortality in patients receiving controlled oxygen therapy; however, this did not reach statistical significance. If a difference in mortality of this order could be confirmed in a larger study the number needed to harm would be of the order of 32. Given the large number of ED presentations and hospital admissions

with COPD annually, this would represent a large number of potentially avoidable deaths. Further research to confirm or refute a mortality difference with controlled oxygen therapy from ED arrival is strongly recommended. It is also interesting to note that the higher mortality in the uncontrolled oxygen group was despite there being a significantly lower proportion of patients on home oxygen, a recognised higher risk group for type II respiratory failure, in that cohort. Cognizant of the limitations of our data collection and methodology, we have resisted the temptation to perform multivariate analysis regarding the mortality outcome controlling for home oxygen status, but this would be an interesting area for future studies. Length of stay was similar to other contemporary reports.[9,10]

There has been some discussion in the literature about the target range.[4] In a recent review, Pilcher *et al.* suggested that further evidence is required to confirm the 88–92% target range. While they agree that oxygen levels outside the normal range (PaO_2 60–100 mmHg) are associated with adverse events in patients with exacerbations of COPD, they suggest that there is an evidence gap regarding adverse event risk within the normoxic range (e.g. SpO_2 88–90% *vs* 90–95%).

This study has some limitations that should be considered when interpreting its results. Data collection was retrospective with potential issues including missing data.[14,15] Because of record availability, accessibility and selection, there is potential selection bias. In part this was because of this being a time-limited registrar research project and not all records were accessible during the available timeframe. We believe that systematic bias is unlikely as records were accessed from a list of eligible patients in date order and omitted if key records were missing. We did not control which patients received controlled versus uncontrolled oxygen therapy. It is possible that the groups differed in ways not identified by this study that had a bearing on outcomes. This is a single health service (two sites) study and may not be generalisable to other sites or health systems. The study has not adequately powered for the mortality outcome.

Conclusion

Patients with exacerbations of COPD receiving controlled oxygen therapy were more likely to achieve SpO_2 within the COPD-X target range of 88–92% and less likely to be over-oxygenated without being more likely to be hypoxic. However, the proportion of patients with SpO_2 within the target range was low, suggesting that further work on processes to optimise oxygenation in this group of patients is needed. There is a trend towards lower mortality with controlled oxygen therapy which is worthy of further research.

Competing interests

A-MK is a member of the editorial board for *Emergency Medicine Australasia*.

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Supporting information

Additional supporting information may be found in the online version of this article at the publisher's web site:

Appendix S1. Data form.