

Audit of Oxygen Therapy in Acute General Medical Wards Following an Educational Programme

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Abstract

Introduction: Previous studies have shown that the administration of supplementary oxygen (O₂) in hospitalised patients outside the intensive care units (ICU) was usually empirical, inappropriate and not in compliance with physiological guidelines. It has been suggested that routine use of portable pulse oximeters in general wards plus in-service education of doctors and nurses may ameliorate this problem. **Materials and Methods:** We introduced the use of pulse oximeters in general wards and instituted an educational programme on O₂ therapy in a University Hospital. We then audited the process of O₂ therapy in 100 consecutive adult medical inpatients. **Results:** We found that, despite an educational programme and the easy availability of pulse oximeters, the quality of O₂ therapy was poor. Half the patients did not receive objective pre-treatment assessment while 43% of patients were not adequately reassessed after O₂ supplementation had been started. The most common error was excess use of O₂ which occurred in 75% of patients. **Conclusion:** The quality of O₂ therapy in the non-ICU setting was poor. Excessive O₂ use was the most common error. We suggest that titration of O₂ therapy, guided by pulse oximeter-guided protocols, may be needed to improve the quality and reduce the cost of O₂ therapy in the hospital. This intervention may best be instituted within the environment of a continuous quality improvement model of health care delivery.

Ann Acad Med Singapore 2000; 29:177-81

Key words: Continuous quality improvement, Inpatients, Pulse oximeter, Supplementary oxygen

Introduction

The rational basis for supplemental oxygen (O₂) treatment is well established. Long-term O₂ therapy improves survival and quality of life in patients with chronic obstructive pulmonary disease who are severely hypoxaemic.^{1,2} Short-term supplemental O₂ is required in medical emergencies and various acute disease states such as respiratory failure, circulatory failure and sepsis. Thus, O₂ is an indispensable supportive modality in ambulances, emergency rooms and intensive care units (ICU). Oxygen therapy is based upon physiological need which is best determined by arterial blood gas measurements.³ According to the American College of Chest Physicians and National Heart, Lung, and Blood Institute (ACCP/NHLBI) Conference on Oxygen Therapy Guidelines, hypoxaemia based on PaO₂ <60 mmHg or oxygen saturation <90% are among the criteria for starting O₂ therapy.^{3,4} Snider and Rinaldo⁵ have published

guidelines for O₂ therapy appropriate for medical patients hospitalised outside the ICU. More recently, the American Association for Respiratory Care⁶ and Stoller et al⁷⁻⁹ have proposed and evaluated more detailed protocols and algorithms based upon a branched-chain logic format respectively.

The advent of pulse oximetry is a major development in critical care medicine. The widespread availability of portable and relatively inexpensive pulse oximeters facilitates the rapid non-invasive evaluation of the need for O₂ therapy, titration of O₂ concentrations and reassessment for withdrawal from O₂ treatment.^{10,11} Routine use of pulse oximeters has been advocated in order to avoid unnecessary oxygen prescriptions and to detect unrecognised hypoxaemia in the course of hospitalisation.¹² The measurement of O₂ saturation using pulse oximetry (SpO₂) is recommended by most current guidelines on O₂

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therapy.⁶⁻⁹ Medical audits in hospitalised patients outside the ICU have consistently shown errors and deficiencies in the institution of O₂ therapy. Small et al¹³ reported that O₂ was more often misused and administered wrongly than antibiotics. Brougher et al⁴ estimated that O₂ therapy prescribed empirically by doctors was less cost-effective than that based upon physiologic guidelines. Albin et al,¹² in 1084 random evaluations of O₂ therapy, found that O₂ was under-prescribed in 20% and over-prescribed in 60% of patients. They suggested that routine use of portable pulse oximeters and more intensive in-service education of nurses and doctors are interventions which may improve compliance with O₂ prescription guidelines.¹²

In this study, we examine the oxygen-prescribing habits and monitoring patterns in our general medical wards following the introduction of portable pulse oximeters and in-service education of nurses and doctors on the appropriate use of O₂ therapy and the need to routinely assess the physiological need for O₂. To date, no studies have addressed this issue locally.

Materials and Methods

One hundred consecutive adult patients, admitted from the Accident and Emergency Department (A&E) to General Medical wards and who were receiving oxygen supplementation, between June and October 1998 at the National University Hospital, Singapore, were included in the study. Patients receiving O₂ during resuscitation, those who were in shock and those with carbon monoxide poisoning as well as patients who required non-invasive ventilatory support either via mask-continuous positive airway pressure (CPAP) or mask-intermittent positive pressure ventilation (IPPV) were excluded from the study.

The following information were collected for each patient:

- 1) the physicians' indications for commencing O₂ therapy from the chart review;
- 2) whether the exact prescriptions were specified by the attending physicians and orders carried out by the nurses;
- 3) whether the oxygenation status (based on either arterial blood gas measurement or pulse oximetry) of the patients was assessed either before or during O₂ treatment; and
- 4) whether the need for continued O₂ supplementation was reviewed.

We measured the oxygen saturation of each patient by pulse oximetry (SpO₂) within 48 hours of hospital admission while O₂ treatment was still in progress. Physicians-in-charge were notified immediately should their patients be found to be hypoxaemic (SpO₂ <90%) or clinically unstable (hypotensive, distressed or drowsy) during the study. For patients with SpO₂ of more than 95% while receiving O₂ therapy, a trial of downtitration of O₂ to room air was

attempted. This O₂ step down was conducted and monitored throughout at the bedside by one of the investigators (KAC). The clinical status of patients including conscious level, respiratory rate, heart rate and blood pressure were monitored to ensure that patients remained clinically stable. Once the SpO₂ readings (with good waveforms on pulse oximeters) had stabilised on ambient air over a 10-minute period and saturations recorded, O₂ therapy was then re-instituted as before. We also collated information on the clinical outcome including mortality, need for intensive care stay and length of hospitalisation.

Oxygen delivery devices used were intranasal oxygen, simple masks, venturi masks and non-rebreather masks. As noted above, we did not study patients who were receiving O₂ from mask-CPAP or mask-IPPV devices. Pulse oximeters employed included PROPAQ 100 series, NELLCOR Symphony N-3000 and Ohmeda Biox 3700. All general medical wards in the hospital had at least one portable pulse oximeter available for use by the physicians-in-charge.

As part of our departmental educational programme, it was compulsory for house staff (interns and residents) to attend a 60-minute discussion on causes of hypoxia and the principles of O₂ therapy which emphasise the need to use physiologic guidelines to guide O₂ therapy.³⁻⁶ The attendance by house staff at such sessions was over 80%. They were also asked to read a chapter on O₂ therapy in acute respiratory failure in a handbook entitled "Survival Guide to Acute Medicine" which was given to all house staff.¹⁴ They were advised to exercise clinical judgement in the application of basic principles, but no formal protocols or guidelines were proposed.¹⁵ They were encouraged to use objective measurements of SpO₂ to assess the need for and response to O₂ treatment and were informed that portable pulse oximeters were easily available in all wards. Nurses had also been trained in the principles of O₂ treatment and use of SpO₂ as part of an in-house respiratory care programme that included a separate 60-minute educational session on O₂ therapy. No formal record of attendance was taken but it was estimated to be more than 50%. Respiratory therapists did not routinely care for patients in the general wards in our hospital and were not involved in this study.

The results are expressed as mean ($\pm$ SD). Student's *t*-test was used to compare differences in continuous variables between groups while the chi-square test was used to compare differences in proportions. A *P* value <0.05 was considered statistically significant.

Results

The mean age of our patients was 64 $\pm$ 16.9 years. Oxygen was most commonly administered to patients with either obstructive airways disease (asthma and chronic

obstructive lung disease) or sepsis (Table I).

There were many deficiencies in the process of O₂ therapy and involving various aspects of its administration (Table II). Of the 100 patients, only 36 (36%) had arterial blood gas analysis measured before O₂ therapy was instituted. The mean arterial pH was 7.42 ± 0.08 , mean pO₂ was 80.1 ± 34.8 mmHg and mean pCO₂ was 38.9 ± 11.5 mmHg in these 36 patients. Out of the 33 patients who had their SpO₂ measured before O₂ was administered, 26 (79%) had SpO₂ $\geq 90\%$ while only 7 (21%) had SpO₂ $< 90\%$. Thus, neither arterial blood analysis nor SpO₂ was measured in half of the patients prior to the institution of O₂ therapy.

The exact oxygen prescription (flow rate and type of delivery device) was not specified in 31 patients. Of the 69 patients in which flow rate was specified, this was adhered to in only 47 (68%) cases. Twelve patients were given oxygen at a higher flow rate than prescribed while 10 were receiving oxygen at a lower flow rate. The correct type of oxygen delivery device was used in all except 1 patient in whom nasal prongs were prescribed but the ventimask was used instead.

Twelve patients did not have their facemasks or intranasal oxygen properly applied on continuously. In 2 of these cases, the oxygen delivery devices were found to be improperly fitted on the face. Oxygen delivery devices were found on the floor in 2 other patients while the oxygen flow was still on. The SpO₂ measured in 1 of them was only 89% (oxygen device was then applied for this patient by the investigator with subsequent improvement in respiratory rate and SpO₂). Eight patients were receiving oxygen on an 'as-needed' basis with oxygen flow adjusted by patients themselves unsupervised. Only 15 of 100 patients had their oxygenation monitored continuously by pulse oximetry.

TABLE I: PATIENT DATA, UNDERLYING DISEASES AND MORTALITY

Age (y) [mean ($\pm$ SD)]	64.1 $\pm$ 16.9	
Sex		
Males	53	
Females	47	
Diagnostic category	No.	No. of deaths (%)
Airway obstruction	37	2 (5)
Infection	30	3 (10)
Cancer	14	2 (14)
Heart failure	7	0
Others*	12	2 (17)
Total	100	9

* This category included stable cerebrovascular accidents, opium withdrawal, renal failure, amyloidosis, hypoglycaemia, peptic ulcer disease and Cushing's syndrome.

Fifty-four patients had their arterial blood gases measured while they were on O₂ therapy. The mean arterial pH was 7.40 ± 0.07 , mean pO₂ was 97.6 ± 42.9 mmHg and mean pCO₂ was 39.0 ± 12.5 mmHg. Thus the efficacy of oxygen supplementation was not evaluated in nearly half (46%) the patients.

The SpO₂ was $< 90\%$ in 3 patients, $> 95\%$ in 75 patients and between 90% to 95% inclusive in the remaining 22. Supplementary oxygen was discontinued by the investigator in the group of 75 patients with SpO₂ $> 95\%$. The SpO₂ reading on room air remained $\geq 90\%$ in all these 75 patients. Thus, the administration of O₂ was inappropriate in 78 patients (too little in 3 and too much in 75).

We compared patients with and without pre-treatment assessment (prior arterial blood gas analysis and/or pulse oximetry measurements) and found no significant differences in age, number of deaths, length of hospital stay or pulse oximetry reading while on oxygen.

Five patients required ICU care during the hospital stay due to deterioration of their primary condition. One of these patients, a 25-year-old man with community-acquired pneumonia, rapidly deteriorated on admission with pulse oximetry reading of 98% at A&E but only 88% on intranasal oxygen flow of 4 L/min half an hour after admission to the general ward. At the time of deterioration, his arterial blood

TABLE II: INCIDENCE OF OMISSIONS AND ERRORS IN THE ADMINISTRATION OF OXYGEN (n = 100)

	No. of patients
No pretreatment assessment (in terms of either ABG or SpO ₂ measured prior to administration of oxygen)	50
No prescription for oxygen (exact flow rate and type of oxygen delivery device was not specified in the treatment charts)	31
No post treatment assessment (in terms of whether ABG or SpO ₂ was checked after oxygen therapy was instituted)	43
Errors during administration, of which:	
-those who received higher flow rate	12
-those who received lower flow rate	10
-those who were given a different oxygen delivery device from that ordered by the physician	1
-those who were not wearing oxygen device properly	12
Total	35
Inappropriate use of oxygen	
-Inadequate O ₂ supplementation*	3
-Excessive O ₂ supplementation**	75
Total	78

* Pulse oximetry reading measured while patients were receiving the prescribed oxygen therapy was $< 90\%$.

** Oxygen was discontinued in 75 patients who had SpO₂ $> 95\%$ while receiving O₂. When breathing room air, these 75 patients had SpO₂ remaining $\geq 90\%$.

gas results were pH 7.233, pCO₂ 49.3 mmHg, pO₂ 72.6 mmHg, O₂ saturation 91.5% on intranasal oxygen flow of 6 L/min. He was admitted to the ICU for ventilatory support but died 35 hours after admission. *Burkholderia pseudomallei* was isolated in his blood cultures.

Nine patients died during the study period. The mean length of hospitalisation was 11 days.

Discussion

We found that the quality of O₂ treatment administered in medical wards was sub-optimal despite the institution of an educational programme and the easy access to portable pulse oximeters. There was no clear rationale and consistency in pre-treatment assessment, prescription orders and compliance as well as post-treatment assessment or monitoring of patients. Oxygen therapy was instituted empirically in most patients. The indications for commencing oxygen were frequently not clear. Oxygenation status was measured in only half of all patients studied prior to the start of O₂ therapy. Even with the exact oxygen order specified, instructions were only followed in 68% of cases. Oxygen continued to be administered in non-hypoxic patients in all of the 75 patients studied. On the other hand, the amount of inspired oxygen administered was insufficient to maintain SpO₂ ≥90% in 3 of the 100 patients. Of these, one was the patient with severe community-acquired pneumonia due to *Burkholderia pseudomallei* and who developed acute respiratory failure requiring intubation. The second patient, a case of chronic obstructive lung disease with chronic type II respiratory failure, had only one arterial blood gas analysis done at inspired oxygen concentration which was higher than that at the time of audit. The last patient had no arterial blood gas analysis at all.

The excessive administration of O₂ therapy in non-hypoxic patients was the most common error detected in this study. This is comparable to the results of other audits which have reported over-prescription rates for O₂ therapy of 38% to 72%.^{4,12,13,16} The inappropriate use of O₂ in non-hypoxic patients will contribute to unnecessary costs to the patient. Currently, the daily charges of O₂ therapy for a non-subsidised patient in the general ward in National University Hospital is \$35 and this amounts to \$385 per patient for the mean hospitalisation stay of 11 days if the need for continuation of O₂ therapy is not reviewed. In addition, although our study did not address this issue, acute supplemental oxygen in patients with chronic Type II respiratory failure can lead to worsening carbon dioxide retention due to abolition of hypoxic drive.¹

This was not a controlled study. Thus, we were unable to directly evaluate the efficacy of our in-house educational programme. Nevertheless, our results are comparable with

that from other audits and suggest that further steps are needed to improve the overall quality and cost-efficacy of O₂ therapy in our institution.^{4,12,13,16} Respiratory therapists do not participate in routine respiratory care of general ward patients in our hospital. It is doubtful, however, if a respiratory therapy service would have a major positive impact in our patients. Albin et al¹² reported a similarly high prevalence of errors in a University hospital where patients were routinely evaluated by respiratory therapists using pulse oximetry twice daily. Moreover, Stoller et al,⁹ in a randomised controlled study of the mandatory respiratory care consult service at the Cleveland Clinic, showed that significantly better adherence to clinical guideline-based algorithms did not necessarily result in better cost-efficacy of respiratory therapy.

Education and the better understanding of complex practice guidelines, protocols and algorithms may not be readily translated into positive changes in the behaviour of medical staff and outcome of patients. This may be partly related to variabilities in motivation, experience and resistance to changes in daily work routines. Less ambitious programmes with narrow, well-defined objectives may be more successful. In this regard, several randomised controlled studies have documented the cost-efficacy of protocol-guided weaning from mechanical ventilation and withdrawal of postoperative O₂ therapy.^{17,18}

In summary, we have found that despite making pulse oximeters widely available and instituting an educational programme for house staff and nurses, the quality of O₂ therapy in non-ICU patients was very poor. Excessive use of O₂ was the most common error and thus should be the target of further intervention to improve quality of care. This may best be instituted within the environment of a continuous quality improvement model of health care delivery by using pulse oximeter-guided protocols.

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