RESPIRATORY CARE Paper in Press. Published on November 6, 2018 as DOI: 10.4187/respcare.06303

Post-Hospitalization Short-Term Oxygen Therapy: Use of a Clinical Management Pathway and Long-Term Follow-Up

Yet Hong Khor MD, Raymond Wong MD, and Christine F McDonald PhD MD

BACKGROUND: Home oxygen therapy is commonly prescribed for patients who remain hypoxemic at hospital discharge, although evidence supporting this practice is lacking. This study aimed to evaluate oxygen prescription and follow-up for patients who were prescribed post-discharge short-term oxygen therapy (STOT) and to assess their long-term outcome. METHODS: A retrospective audit was undertaken of subjects prescribed STOT following hospitalization at a single site in Melbourne, Australia, between January 2011 and December 2015. During the study period, a designated clinical pathway for STOT prescription and follow-up after hospital discharge was in place. Chart review was performed to collect subject demographics and comorbidities, results of oxygen assessment (arterial blood gas and 6-min walk tests) and prescription, and results at follow-up re-assessment and mortality. RESULTS: Over five 5 years, 205 subjects were prescribed STOT upon hospital discharge. Common indications for oxygen treatment were chronic lung disease (54%) and dyspnea palliation (26%). Of the 152 subjects who were discharged with non-palliative oxygen therapy, 28% did not fulfil the recommended prescribing criteria or did not have recommended assessments. Among the 118 subjects who attended for re-assessment 4 weeks after initial oxygen provision, 47 (40%) did not fulfill criteria for long-term oxygen therapy. The 1-y cumulative survival rate for the study population was 56%. CONCLUSIONS: A significant proportion of subjects who were prescribed post-discharge STOT did not fulfill the recommended prescribing criteria. The long-term prognosis for subjects who were prescribed post-discharge STOT was poor. *Key words: oxygen; short-term oxygen therapy; long-term oxygen therapy; post-discharge; COPD; palliative care; prognosis.* [Respir Care 0;0(0):1–•. © 0 Daedalus Enterprises]

Introduction

Hypoxemia is common in patients hospitalized with a range of acute illnesses, but it usually resolves within days to weeks of treatment of the underlying disorder. Short-term oxygen therapy (STOT) is often prescribed for patients who remain hypoxemic at hospital discharge, although there are no studies to support this practice. As a consequence, criteria for assessing eligibility for home oxygen therapy during hospitalization are not standardized and are often adapted directly from those used for determining eligibility for long-term oxygen therapy. Although the benefits of long-term oxygen therapy have been established in patients with stable COPD and resting hypoxemia, its clinical benefits in patients with hypoxemia following hospitalization are uncertain. In addition to its cost, oxygen therapy may cause significant adverse effects including oxygen toxicity, physical limitations with decreased mobility and increased falls risk, social stigma, nasal irritation, and fire hazards.

The Fifth Oxygen Consensus Conference recommended that patients discharged with STOT following hospitalization be assessed for continued eligibility for long-term oxygen therapy within 90 d of discharge.[1] Current guide-

All authors are affiliated with the Department of Respiratory and Sleep Medicine, Austin Health, Heidelberg, Victoria, Australia, and Institute for Breathing and Sleep, Heidelberg, Victoria, Australia.

Dr Khor has disclosed relationships with Air Liquide, Boehringer Ingelheim, and the National Health and Medical Research Council. Dr McDonald has disclosed relationships with Boehringer Ingelheim, Novartis, GSK, Pfizer, Menarini, and Air Liquide. Dr Wong has disclosed no conflicts of interest.

Correspondence: Yet H Khor MD, Department of Respiratory and Sleep Medicine, Austin Health, 145 Studley Road, Heidelberg 3084 VIC, Australia. E-mail: yethong.khor@austin.org.au.

DOI: 10.4187/respcare.06303

RESPIRATORY CARE Paper in Press. Published on November 6, 2018 as DOI: 10.4187/respcare.06303

lines from the Thoracic Society of Australia and New Zealand and the British Thoracic Society recommend reassessment within a similar timeframe.[2,3] Previous studies reported that up to 58% of subjects who were prescribed STOT at hospital discharge did not fulfill criteria for long-term oxygen therapy during follow-up assessment.[4-7] It is also noted that relatively few subjects (35–65%) underwent appropriate reassessments for eligibility for long-term oxygen therapy following hospital discharge.[4,8,9] Post-discharge STOT has been identified by the American Thoracic Society and American College of Chest Physicians as one of the top 5 areas in adult pulmonary medicine requiring improved delivery of care.[10]

A clinical pathway is used at our institution for the assessment and management of patients referred for post-discharge STOT. We performed this audit to evaluate the use of the clinical pathway in the assessment, management, and follow-up of subjects discharged with STOT following hospital admission. In addition, we examined predictors for the ongoing requirement of long-term oxygen therapy and the prognosis for subjects who were prescribed post-discharge STOT.

QUICK LOOK

Current knowledge

Short-term oxygen therapy is commonly prescribed for patients who remain hypoxemic at hospital discharge, although there is a lack of evidence supporting this practice. Previous studies reported a significant proportion of subjects who no longer met eligibility criteria for long-term oxygen therapy at reassessments, and 35-65% failed to attend follow-up appointments.

What this paper contributes to our knowledge

Despite the use of a clinical pathway, 30% of subjects discharged with short-term oxygen therapy did not have appropriately detailed oxygen assessments or did not meet recommended prescribing criteria. Optimal medical care was not offered to subjects with COPD. The long-term prognosis for subjects who were discharged with short-term oxygen therapy was poor.

Methods

A retrospective audit of subjects prescribed STOT following hospitalization at Austin Health, a tertiary Victorian hospital, between January 2011 and December 2015 was performed. This study was approved by the Austin Health Human Research Ethics Committee (LNR/17/Austin/352).

At Austin Health, a standardized referral form to the oxygen therapy clinic is used to prescribe STOT at hospital discharge. A routine follow-up appointment at the oxygen therapy clinic after 4 weeks post-discharge is scheduled once the referral has been processed. Prescribing criteria for STOT at hospital discharge are based on the guidelines from the Thoracic Society of Australia and New Zealand for long-term oxygen therapy (Table 1).[3] Similar prescribing criteria are used for prescription of ongoing long-term oxygen therapy and exertional oxygen therapy at the follow-up assessments. Education regarding oxygen therapy is provided by a nurse educator to all patients prior to discharge, and oxygen equipment is delivered to the discharge destination by the designated oxygen service provider.

Data collected from the hospital-scanned medical record included patient demographics, referring medical units, diagnosis, types of oxygen therapy prescribed (ie, continuous, exertional, nocturnal, or palliative oxygen therapy), major comorbidities, details of initial and follow-up oxygen assessments (ie, 6-min walk test, arterial blood gases, sleep study), lung function tests (ie, spirometry, gas transfer), length of hospital stay, and mortality. For subjects with COPD, additional information on medical therapies and participation in pulmonary rehabilitation were collected.

Statistical analyses were performed using Graphpad Prism (v5, Graphpad Software, San Diego, California) and SPSS (v23, IBM, Armonk, New York). Categorical variables were expressed as absolute number (frequencies). The Fisher exact test was used to compare frequencies between groups. Data distributions were tested for normality using the Kolmogorov-Smirnov test. Parametric distributions were analyzed with *t* tests for comparisons of the 2 groups. For nonparametric data, the Mann-Whitney test was used for 2-group comparisons. Statistical significance was accepted at $P < .05$. Potential predictors for requirement of long-term oxygen therapy at follow-up assessments were evaluated using univariate logistic regression analyses. Selection of variables was based on factors considered to predict persistent hypoxemia and long-term requirement for oxygen therapy, including age, gender, co-existing cardiorespiratory comorbidities, smoking history, lung function, baseline oxygen assessment results (ie, 6-min walk distance and nadir saturation, arterial blood gas), evidence of chronic hypoxemia, and number of hospitalizations in the preceding 12 months. Kaplan-Meier analyses were performed to estimate subject survival.

Results

A total of 205 subjects were included in the analysis. Baseline characteristics of the subjects are shown in

RESPIRATORY CARE Paper in Press. Published on November 6, 2018 as DOI: 10.4187/respcare.06303

Table 1. Prescribing Criteria for Home Oxygen Therapy

Type of Oxygen Therapy	Prescribing Criteria
Continuous oxygen therapy	Resting $P_{aO_2} \leq 55$ mm Hg; OR Resting P_{aO_2} 56–59 mm Hg with evidence for hypoxic organ damage (including right heart failure, pulmonary hypertension, or polycythemia)
Exertional oxygen therapy	Exertional desaturation to S_{pO_2} during a 6-min walk test while breathing room air; AND A demonstrable improvement in exercise performance or symptoms on supplemental oxygen therapy
Nocturnal oxygen therapy	Consultation with the respiratory unit; AND Evidence of oxygen desaturation to $S_{pO_2} \leq 88\%$ for more than one third of the sleep time based on continuous overnight S_{pO_2} monitoring during sleep
Palliative oxygen therapy	Resting $S_{pO_2} < 90\%$; AND A life expectancy of < 3 months

Table 2. Baseline Subject Characteristics

Variables	Values
Age, y	75 (68–83)
Female:male ratio, *n*	86:119
Length of stay, d	10 (7–18)
Smoking history, *n* (%)	
Ex-smoker	145 (71)
Never smoker	60 (29)
Diagnosis, including comorbidities, *n* (%)	
COPD	118 (58)
Congestive cardiac failure	80 (39)
Malignancy	70 (34)
Diabetes mellitus	51 (25)
Interstitial lung disease	46 (22)
Sleep-disordered breathing	21 (10)
Pulmonary embolism	11 (5)
Bronchiectasis	11 (5)
Asthma	5 (2)
Evidence of chronic hypoxemia, *n* (%)	
Right heart failure	48 (23)
Polycythemia	6 (3)
Pulmonary hypertension	71 (35)

N = 205 subjects
Age and length of stay are shown as median (interquartile range).

Table 2. The study population was predominantly male (58%) with a median age of 75 y with an interquartile range (IQR) of 68–83. The majority of subjects were admitted under respiratory medicine (29%), general medicine (20%), and medical oncology (20%). The median length of hospital stay was 10 d (IQR 7–18). Thirty-four (17%) subjects were re-admitted within 6 weeks following discharge from the initial hospitalization. Of the 205 subjects, 181 subjects were prescribed continuous oxygen therapy (of whom 135 [75%] were also prescribed exertional oxygen therapy), 22 subjects were prescribed exertional oxygen therapy only, and 2 subjects were prescribed nocturnal and exertional oxygen therapy.

Table 3. Proportion of Subjects Prescribed Home Oxygen Therapy at Hospital Discharge Who Had Appropriate In-Patient Assessment

Therapy vs. Assessment		Subjects, *n* (%)
Therapy	Continuous oxygen therapy	137
Assessment	Arterial blood gas assessment	114 (83)
Therapy	Exertional oxygen therapy only	13
Assessment	6-min walk test	11 (85)
Therapy	Nocturnal oxygen therapy	2
Assessment	Sleep study assessment	2 (100)

Indications for Oxygen Therapy

The most common indication for STOT at hospital discharge was chronic lung disease (111 subjects: COPD = 70 subjects; interstitial lung disease = 33 subjects; dual lung pathologies = 5 subjects; bronchiectasis = 3 subjects). Post-discharge oxygen therapy was requested for 53 (26%) subjects for palliation (malignancy = 43 subjects; congestive cardiac failure = 5 subjects; COPD = 4 subjects; interstitial lung disease = 1 subject). Other indications for STOT included congestive cardiac failure (16 subjects), chronic hypoventilation syndrome (10 subjects), co-existing COPD and congestive cardiac failure (5 subjects), acute respiratory illnesses (pulmonary embolism = 3 subjects; pneumonia = 2 subjects), hepatopulmonary syndrome (3 subjects), and pulmonary arterial hypertension (2 subjects).

In-Patient Assessments

Of the 152 subjects who were discharged with nonpalliative oxygen therapy, 127 (84%) had appropriate oxygen assessments during hospitalization (Table 3). Both subjects who were prescribed nocturnal oxygen therapy underwent sleep studies during hospitalization for acute on chronic respiratory failure after medical stabilization.

RESPIRATORY CARE Paper in Press. Published on November 6, 2018 as DOI: 10.4187/respcare.06303

Table 4. Proportion of Subjects Prescribed Home Oxygen Therapy at Hospital Discharge Who Did Not Fulfill the Recommended Prescribing Criteria

Therapy vs. Assessment		Subjects, *n* (%)
Therapy	Continuous oxygen therapy	41
Assessment	Did not have arterial blood gas assessment	23 (56)
Assessment	Did not have significant resting hypoxemia	18 (44)
Therapy	Exertional oxygen therapy only	2
Assessment	Did not have a 6-min walk test assessment	2 (100)

Table 4 shows the proportions of subjects who did not meet recommended prescribing criteria for different types of oxygen therapy. Overall, 43 (29%) subjects who were prescribed STOT did not fulfill recommended prescribing criteria (18 [12%] had no significant resting hypoxemia) or did not have recommended assessments (23 [15%] had no arterial blood gas tests, and 2 [1%] did not perform a 6-min walk test).

Follow-up Assessments

Of the 190 subjects who survived > 30 d after hospital discharge, 118 (62%) appeared for follow-up assessment. The median time between hospital discharge and follow-up was 45 (IQR 38–60) d. Of the subjects who were prescribed post-discharge STOT for dyspnea palliation and survived > 30 d (42 subjects), only 6 (14%) had re-assessment. There were no significant differences in the attendance rates for follow-up assessments among subjects with various cardiopulmonary diseases. Compared to subjects who did not have follow-up assessments, those who underwent review were more likely to have baseline evidence of sequelae of chronic hypoxemia, including polycythemia, pulmonary hypertension, and right heart failure (55% vs 23%, $P < .001$), and they had a lower gas transfer factor (diffusing capacity of the lung for carbon monoxide 42% predicted [IQR 36–48] vs 48% predicted [IQR 39.5–55.5], $P = .009$).

Among the 118 subjects who attended the follow-up assessments, 47 (40%) no longer fulfilled criteria for long-term oxygen therapy; 51 (43%) subjects continued to fulfill criteria for continuous oxygen therapy, and 20 (17%) fulfilled the criteria for exertional oxygen therapy only. In the univariate logistic regression analyses, there was a significant association between lower P_{aO_2} values at hospital discharge and ongoing requirements for long-term oxygen therapy (Table 5).

Table 5. Univariate Logistic Analysis of Potential Baseline Predictors for Fulfilling Criteria for Long-Term Oxygen Therapy at Follow-up Assessments

Variables	Odds Ratio (95% CI)	*P*
Age	0.99 (0.96–1.02)	.54
Gender	0.55 (0.25–1.19)	.13
Coexisting cardiorespiratory comorbidities	1.06 (0.49–2.28)	.89
Smoking history	0.76 (0.32–1.79)	.53
FEV_1, % predicted	1.00 (0.99–1.02)	.78
FVC, % predicted	1.00 (0.98–1.01)	.67
D_{LCO}, % predicted	1.00 (0.96–1.04)	> .99
6-min walk distance, m	1.00 (0.99–1.01)	.49
6-min walk test nadir saturation, %	0.99 (0.94–1.05)	.82
P_{aO_2}	0.90 (0.84–0.96)	.002
P_{aCO_2}	1.04 (0.99–1.08)	.10
Evidence of chronic hypoxemia*	1.69 (0.77–3.71)	.19
Number of hospital admissions in previous 12 months	1.14 (0.85–1.53)	.39

D_{LCO} = diffusing capacity of the lung for carbon monoxide
* Evidence of chronic hypoxemia includes the presence of any of the following: right heart failure, polycythemia, or pulmonary hypertension.

Management of COPD

COPD ($n = 75$) was the most common primary diagnosis in this study population. Among the subjects with a primary diagnosis of COPD, 61 (81%) were treated with inhaled corticosteroids and dual bronchodilators, and 4 were discharged without any inhaler therapy. The remaining subjects were treated with a combination therapy of inhaled corticosteroids and long-acting beta agonists ($n = 6$) or long-acting muscarinic agonists only ($n = 4$). Only 29 subjects (39%) were referred for pulmonary rehabilitation.

Mortality

Fifteen subjects died within 30 d after hospital discharge. Figure 1 shows the overall cumulative survival rate for the study population. The overall 1-y cumulative survival rate for subjects discharged with STOT was 56%. For subjects who were prescribed nonpalliative oxygen therapy, the 1-y cumulative survival rate was 61%. The median post-discharge survival duration for subjects who were prescribed palliative and nonpalliative oxygen therapy was 49 d and 984 d, respectively.

Discussion

This study highlights issues inherent with STOT prescription at hospital discharge. Detailed oxygen assess-

RESPIRATORY CARE Paper in Press. Published on November 6, 2018 as DOI: 10.4187/respcare.06303

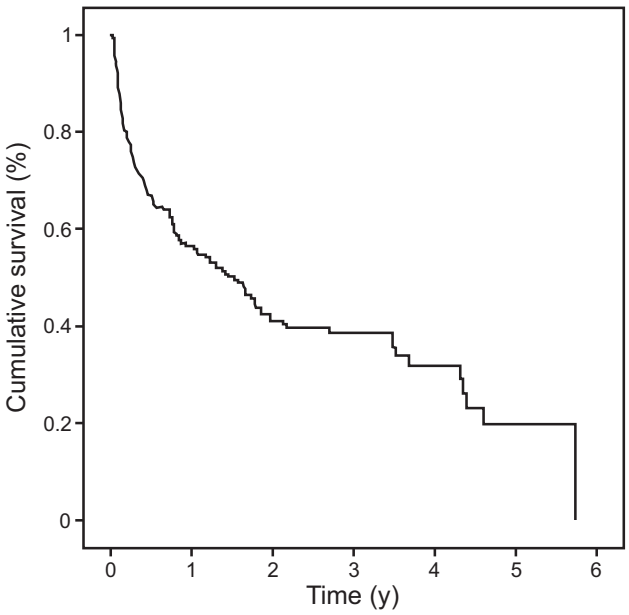

Fig. 1. Kaplan-Meier analysis for survival of the study population over time.

ments were often incomplete, and adherence to recommended prescribing criteria was suboptimal. A significant proportion of subjects failed to attend their review appointments for reassessment for long-term oxygen therapy eligibility. Among those who attended the follow-up review, 40% no longer fulfilled criteria for long-term oxygen therapy. Apart from underlying chronic lung diseases, palliation of dyspnea (predominantly relating to malignancy) was a common indication for prescribing STOT following hospitalization. The majority of subjects with COPD who were discharged with STOT were not referred for pulmonary rehabilitation. The long-term prognosis for subjects who were prescribed STOT at hospital discharge was poor.

There is a lack of evidence concerning the need for STOT at hospital discharge in the presence of continuing hypoxemia following an acute illness; however, it is a common practice due to clinical concerns about the potential risks associated with ongoing hypoxemia. There is accumulating evidence that hyperoxia due to oxygen therapy may lead to worse clinical outcomes in acute illnesses where physiological intuition might have suggested a beneficial response. Hyperoxia has been shown to be associated with increased mortality in patients with cardiac arrest,[11,12] stroke,[13] acute myocardial infarction,[14] and septic shock.[15] Breathing 30–60 min of supplementary oxygen at 28% has been shown to lead to elevated systemic and airway markers of oxidative stress and inflammatory cytokines in both healthy volunteers and patients with COPD.[16,17] In addition, hyperoxia has been shown to be associated with acute lung injury and bacterial dissemination in animal models.[18-21] Further research to assess the effects of home oxygen therapy in patients with recent acute illnesses is needed to guide our practice.

Despite the presence of a designated pathway for assessment and follow-up of subjects discharged with STOT following hospitalization, in-hospital assessments lacked essential data or did not adhere to recommended prescribing criteria in a significant proportion of subjects. Approximately 17% of subjects did not undergo a baseline arterial blood gas measurement prior to discharge on continuous oxygen therapy, and 13% did not exhibit sufficient hypoxemia to warrant such therapy. This suggests that more attention should be paid to educating in-patient medical teams about the need for adequate assessment and prescription to avoid inappropriate use of STOT. Given that a significant proportion of subjects did not meet eligibility criteria for long-term oxygen therapy at reassessment, patient education should also be provided prior to hospital discharge to emphasize the likely short-term nature of home oxygen therapy post-discharge and the importance of reassessment. It is known that patients can develop psychological dependence on oxygen therapy.[22] Realistic expectations of the effects of STOT and the likely potential withdrawal of the therapy after reassessment should be discussed.

Although hospital readmission rates in patients with exacerbations of COPD have been reported to be reduced with the use of oxygen therapy as part of a post-hospitalization multicomponent care program,[23] there are conflicting results from retrospective studies on the impact of long-term oxygen therapy on hospitalization rates.[24-27] Nevertheless, some health care professionals perceive that oxygen therapy may prevent potential hospital readmissions by improving recovery or managing relapses at home. It is possible that the use of home oxygen therapy may result in increased health care utilization for support or due to falls or oxygen toxicity as a result of its use. It is important to consider other management methods to optimize patient care following hospitalization. Pulmonary rehabilitation following exacerbation of COPD has been shown to improve patients' health-related quality of life and exercise capacity, with potential to reduce hospital readmissions.[28] However, only 39% of subjects with COPD in this study were referred for pulmonary rehabilitation.

Post-discharge STOT was commonly prescribed for palliation of symptoms. This finding is in agreement with results from previous qualitative studies on physicians' perspectives on oxygen therapy.[29] Although oxygen therapy has been shown to relieve breathlessness during laboratory-based exercise tests in patients with COPD who were mildly or non-hypoxemic, it has not been shown to improve symptoms or quality of life in the home setting.[30] A previous randomized controlled trial found that palliative oxygen was not superior to room air for relieving

RESPIRATORY CARE Paper in Press. Published on November 6, 2018 as DOI: 10.4187/respcare.06303

dyspnea in subjects with life-limiting illness and refractory dyspnea without significant hypoxemia.[31] More importantly, oxygen therapy poses significant physical and psychological burdens on both the patients with life-limiting illnesses and their caregivers.[32,33] A detailed discussion of the potential effects of oxygen therapy should be provided to patients and their carers prior to prescribing. The use of alternative pharmacologic and nonpharmacologic strategies should be considered for managing refractory breathlessness in this group of patients.

The prognosis for subjects who were discharged with STOT following hospitalization was poor. The overall 1-y survival rate of 61% for the nonpalliative subjects was comparable with previously reported data for subjects hospitalized for heart failure and COPD, which ranged from 56% to 67%[34-37] and from 55% to 78%,[38-42] respectively. A cohort study of a sample of Medicare beneficiaries > 65 y old from the United States reported 3-y mortality rate of 39.5% for those who were admitted to the ICU during hospitalization.[43] Our results suggest that patients prescribed with STOT at hospital discharge are at high risk of poor outcomes. This might be due to a high rate of multimorbidity, as noted in our study.

This study has some limitations. This study was conducted in a single institution. Nonetheless, all subjects managed by different medical units within the institution were included for analysis. Due to the retrospective nature of the study, there were missing data due to incomplete assessments. This highlighted the deficits in the current management pathway for this group of patients. Given the lack of standardized criteria for prescribing STOT at hospital discharge, our findings may not be generalizable to other hospitals. However, the prescribing criteria we use for STOT following hospitalization are commonly used at other institutions. In addition, rates of subjects in this study who both failed to attend for reassessment and no longer fulfilled prescribing criteria for long-term oxygen therapy at reassessment are comparable to those of previous studies. This suggests that our study population may be representative.

Conclusions

This study highlighted significant issues with the prescription and management of STOT for patients with hypoxemia at hospital discharge. Adherence to the clinical pathway for assessment and prescription of STOT following hospitalization was poor. There is a clear need to prospectively evaluate the effects of STOT in patients with hypoxemia following hospitalization to guide clinical practice. Strategies for educating clinicians and patients regarding the roles of home oxygen therapy following hospitalization should be implemented to improve both patient care and health care delivery.

REFERENCES

1. Petty TL, Casaburi R. Recommendations of the Fifth Oxygen Consensus Conference. Writing and Organizing Committees. Respir Care 2000;45(8):957-961.
2. Hardinge M, Annandale J, Bourne S, Cooper B, Evans A, Freeman D, et al.; British Thoracic Society Home Oxygen Guideline Development Group; British Thoracic Society Standards of Care Committee. British Thoracic Society guidelines for home oxygen use in adults. Thorax 2005;70(Suppl 1):i1–i43.
3. McDonald CF, Whyte K, Jenkins S, Serginson J, Frith P. Clinical Practice Guideline on Adult Domiciliary Oxygen Therapy: Executive summary from the Thoracic Society of Australia and New Zealand. Respirology 2016;21(1):76-78.
4. Oba Y, Salzman GA, Willsie SK. Reevaluation of continuous oxygen therapy after initial prescription in patients with chronic obstructive pulmonary disease. Respir Care 2000;45(4):401-406.
5. Eaton TE, Grey C, Garrett JE. An evaluation of short-term oxygen therapy: the prescription of oxygen to patients with chronic lung disease hypoxic at discharge from hospital. Respir Med 2001;95(7):582-587.
6. Chaney JC, Jones K, Grathwohl K, Olivier KN. Implementation of an oxygen therapy clinic to manage users of long-term oxygen therapy. Chest 2002;122(5):1661-1667.
7. Guyatt GH, Nonoyama M, Lacchetti C, Goeree R, McKim D, Heels-Ansdell D, Goldstein R. A randomized trial of strategies for assessing eligibility for long-term domiciliary oxygen therapy. Am J Respir Crit Care Med 2005;172(5):573-580.
8. Morrison D, Skwarski K, MacNee W. Review of the prescription of domiciliary long term oxygen therapy in Scotland. Thorax 1995;50(10):1103-1105.
9. Ringbaek TK, Lange P. The impact of the Danish Oxygen Register on adherence to guidelines for long-term oxygen therapy in COPD patients. Respir Med 2006;100(2):218-225.
10. Wiener RS, Ouellette DR, Diamond E, Fan VS, Maurer JR, Mularski RA, et al. An official American Thoracic Society/American College of Chest Physicians Policy Statement. The choosing wisely top five list in adult pulmonary medicine. Chest 2014;145(6):1383-1391.
11. Kilgannon JH, Jones AE, Shapiro NI, Angelos MG, Milcarek B, Hunter K, et al. Association between arterial hyperoxia following resuscitation from cardiac arrest and in-hospital mortality. JAMA 2010;303(21):2165-2171.
12. Janz DR, Hollenbeck RD, Pollock JS, McPherson JA, Rice TW. Hyperoxia is associated with increased mortality in patients treated with mild therapeutic hypothermia after sudden cardiac arrest. Crit Care Med 2012;40(12):3135-3139.
13. Rincon F, Kang J, Maltenfort M, Vibbert M, Urtecho J, Athar MK, et al. Association between hyperoxia and mortality after stroke: a multicenter cohort study. Crit Care Med 2014;42(2):387-396.
14. Calbello JB, Burls A, Emparanza JI, Bayliss SE, Quinn T. Oxygen therapy for acute myocardial infarction. Cochrane Database Syst Rev 2016;12:CD007160.
15. Asfar P, Schortgen F, Boisramé-Helms J, Charpentier J, Guérot E, Megarbane B, et al. Hyperoxia and hypertonic saline in patients with septic shock (HYPERS2S): a two-by-two factorial, multicentre, randomised, clinical trial. Lancet Respir Med 2017;5(3):180-190.
16. Carpagnano GE, Kharitonov SA, Foschino-Barbaro MP, Resta O, Gramiccioni E, Barnes PJ. Supplementary oxygen in healthy subjects and those with COPD increases oxidative stress and airway inflammation. Thorax 2004;59(12):1016-1019.
17. Phillips M, Cataneo RN, Greenberg J, Grodman R, Gunawardena R, Naidu A. Effect of oxygen on breath markers on oxidative stress. Eur Respir J 2003;21(1):48-51.

RESPIRATORY CARE Paper in Press. Published on November 6, 2018 as DOI: 10.4187/respcare.06303

18. Beck JM, Preston AM, Wilcoxen SE, Morris SB, White ES, Paine R 3rd. Pneumocystis pneumonia increases the susceptibility of mice to sublethal hyperoxia. Infect Immun 2003;71(10):5970-5978.
19. Tateda K, Deng JC, Moore TA, Newstead MW, Paine R 3rd, Kobayashi N, et al. Hyperoxia mediates acute lung injury and increased lethality in murine Legionella pneumonia: the role of apoptosis. J Immunol 2003;170(8):4209-4216.
20. Nara C, Tateda K, Matsumoto T, Ohara A, Miyazaki S, Standiford TJ, Yamaguchi K. Legionella-induced actue lung injury in the setting of hyperoxia: protective role of tumour necrosis factor-alpha. J Med Microbiol 2004;53(Pt 8):727-733.
21. Kikuchi Y, Tateda K, Fuse ET, Matsumoto T, Gotoh N, Fukushima J, et al. Hyperoxia exaggerates bacterial dissemination and lethality in *Pseudomonas aeruginosa* pneumonia. Pulm Pharmacol Ther 2009; 22(4):333-339.
22. Kelly CA, Maden M. How do respiratory patients perceive oxygen therapy? A critical interpretative synthesis of the literature. Chron Respir Dis 2014;11(4):209-228.
23. Couglin S, Liang WE, Parthasarathy S. Retrospective assessment of home ventilation to reduce rehospitalization in chronic obstructive pulmonary disease. J Clin Sleep Med 2015;11(6):663-670.
24. Ringbaek TJ, Viskum K, Lange P. Does long-term oxygen therapy reduce hospitalisation in hypoxaemic chronic obstructive pulmonary disease? Eur Respir J 2002;20(1):38-42.
25. Ringbaek TJ, Fabricius P, Lange P. The effect of home oxygen therapy on hospitalization in moderate hypoxaemic COPD. Chron Respir Dis 2005;2(2):107-8.
26. Turner AM, Sen S, Steeley C, Khan Y, Sweeney P, Richards Y, Mukherjee R. Evaluation of oxygen prescription in relation to hospital admission rate in patients with chronic obstructive pulmonary disease. BMC Pulm Med 2014;14:127.
27. Cho KH, Kim YS, Nam CM, Kim TH, Kim SJ, Han KT, Park EC. Home oxygen therapy reduces risk of hospitalisation in patients with chronic obstructive pulmonary disease: a population-base retrospective cohort study, 2005-2012. 2015;BMJ Open 5(11):e009065.
28. Puhan MA, Gimeno-Santos E, Cates CJ, Troosters T. Pulmonary rehabilitation following exacerbations of chronic obstructive pulmonary disease. Cochrane Database Syst Rev 2016;12:CD005305.
29. Kelly CA, Maden M. How do health-care professionals perceive oxygen therapy? A critical interpretive synthesis of the literature. Chron Respir Dis 2015;12(1):11-23.
30. Ekström M, Ahmadi Z, Bornefalk-Hermansson A, Abernethy A, Currow D. Oxygen for breathlessness in patients with chronic obstructive pulmonary disease who do not qualify for home oxygen therapy. Cochrane Database Syst Rev 2016;11:CD006429.
31. Abernethy AP, McDonald CF, Frith PA, Clark K, Herndon JE 2nd, Marcello J, et al. Effect of palliative oxygen versus room air in relief of breathlessness in patients with refractory dyspnoea: a double-blind, randomised controlled trial. Lancet 2010;376(9743):784-793.
32. Jaturapatporn D, Moran E, Obwanga C, Husain A. Patients' experience of oxygen therapy and dyspnea: a qualitative study in home palliative care. Support Care Cancer 2010;18(6):765-770.
33. Collier A, Breaden K, Phillips JL, Agar M, Litster C, Currow DC. Caregivers' perspectives on the use of long-term oxygen therapy for the treatment of refractory breathlessness: a qualitative study. J Pain Symptom Manage 2017;53(1):33-39.
34. Blackledge HM, Tomlinson J, Squire IB. Prognosis for patients newly admitted to hospital with heart failure: survival trends in 12,220 index admissions in Leicestershire 1993-2001. Heart 2003;89(6): 615-620.
35. Golberg RJ, Ciampa J, Lessard D, Meyer TE, Spencer FA. Long-term survival after heart failure: a contemporary population-based perspective. Arch Intern Med 2007;167(5):490-496.
36. Ko DT, Alter DA, Austin PC, You JJ, Lee DS, Qiu F, et al. Life expectancy after an index hospitalization for patients with heart failure: a population-based study. Am Heart J 2008;155(2):324-331.
37. Jhund PS, MacIntyre K, Simpson CR, Lewsey JD, Stewart S, Redpath A, et al. Long-term trends in first hospitalization for heart failure and subsequent survival between 1986 and 2003: a population study of 5.1 million people. Circulation 2009;119(4):515-523.
38. Hajizadeh N, Goldfeld K, Crothers K. What happens to patients with COPD with long-term oxygen treatment who receive mechanical ventilation for COPD exacerbation? A 1-year retrospective follow-up study. Thorax 2015;70(3):294-296.
39. Ho TW, Tsai YJ, Ruan SY, Huang CT, Lai F, Yu CJ, on behalf of the HINT Study Group. In-hospital and one-year mortality and their predictors in patients hospitalized for first-ever chronic obstructive pulmonary disease exacerbations: a nationwide population-based study. PLoS One 2014;9(12):e114866.
40. Groenewegen KH, Schols AM, Wouters EF. Mortality and mortality-related factors after hospitalization for acute exacerbation of COPD. Chest 2003;124(2):459-467.
41. Almagro P, Calbo E, Ochoa de Echaguen A, Barreiro B, Quintana S, Heredia JL, Garau J. Mortality after hospitalization for COPD. Chest 2002;121(5):1441-1448.
42. Connors AF Jr, Dawson NV, Thomas C, Harrell FE Jr, Desbiens N, Fulkerson WJ, et al. Outcomes following acute exacerbation of severe chronic obstructive disease. The SUPPORT investigators (Study to Understand Prognoses and Preferences for Outcomes and Risks of Treatments). Am J Respir Crit Care Med 1996;154(4 Pt 1):959-967.
43. Wunsch H, Guerra C, Barnato AE, Angus DC, Li G, Linde-Zwirble WT. Three-year outcomes for Medicare beneficiaries who survive intensive care. JAMA 2010;303(9):849-856.