

Title Page

Smoking Related Home Oxygen Burn Injuries: Continued Cause for Alarm

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Key words: smoking; home oxygen therapy; COPD; combustion injury; burns; substance abuse

Author contributions:

WGC, MSB, KM, and AMT had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. MSB, AMT, WGC contributed to the design of the review database and decisions of data-points collected. MSB, AMT, WGC, KM, GTB contributed to data analysis. MSB, AMT, WGC, GTB, RS contributed to manuscript preparation.

Financial/nonfinancial disclosures: The authors have no potential conflicts of interest with any companies/organizations whose products or services may be discussed in this article. All ethical standards have been adhered to and respected.

This is the author's manuscript of the article published in final edited form as:

Carlos, W. G., Baker, M. S., McPherson, K. A., Bosslet, G. T., Sood, R., & Torke, A. M. (2016). Smoking-Related Home Oxygen Burn Injuries: Continued Cause for Alarm. *Respiration*, 91(2), 151–155. <http://doi.org/10.1159/000443798>

Funding: This work was supported by the Charles Warren Fairbanks Center for Medical Ethics, which is funded by the Richard M. Fairbanks Foundation and the Methodist Health Foundation, all located in Indianapolis, Indiana

Notation of prior abstract publication/presentation: ACCP Annual conference, Chest 2014, Austin, TX, oral presentation of original research while in progress

Running Head: Morbidity Analysis: Burns from Smoking on Oxygen

Descriptor Number: 6.17

Mesh Headings: Pulmonary Disease, Chronic Obstructive; Burns, Inhalation

Total Word Count (Body): 1715

For Peer Review

1 **Abstract**

2 Introduction: Home oxygen therapy is a mainstay of treatment for patients with various
3 cardiopulmonary diseases. In spite of warnings against smoking while using home oxygen,
4 many patients sustain burn injuries warranting hospital admission. We quantified the
5 morbidity and mortality of such patients admitted to our regional burn unit over a 6-year
6 period.

7 Methods: A retrospective chart review of all patients admitted to a regional burn center from
8 2008-2013 was completed. Admitted patients sustaining burns secondary to smoking while
9 using home oxygen therapy were selected as the study population. This population was then
10 analyzed to determine morbidity based on standard criteria.

11 Results:

12 We identified 55 subjects admitted to the burn unit for smoking related home oxygen injuries.
13 Age range was 40-84 years. Almost all subjects were on home oxygen for COPD (96%) and 79%
14 of the burn injuries involved flow rates of 3L or higher. Seventy-two percent of burns involved
15 less than 5% TBSA, 51% of patients were intubated, and of those 33% had evidence of
16 inhalation injury. The hospital mortality rate was 14.5%. Mean length of hospital stay was 8.6
17 days and 54.5% were discharged to a nursing home or other advanced facility. Finally,
18 concomitant substance abuse was found in 27% and a previous history of injury from smoking
19 while on home oxygen was discovered in 14.5%.

20 Conclusions: This single center analysis is one of the largest describing burn injuries stemming
21 from smoking while using home oxygen therapy. We identified significant morbidity and
22 mortality associated with these injuries in spite of low total body surface involvement. Despite
23 efforts to counsel patients on the possibility of combustion injuries secondary to smoking on
24 home oxygen these injuries continue to be prevalent. Ongoing education and careful
25 consideration of prescribing home oxygen therapy for known smokers is highly encouraged.

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38 **Text**

39 **Introduction:**

40 Home oxygen therapy (HOT) is a common treatment employed for patients
41 demonstrating hypoxemia from various cardiopulmonary diseases. Of these diseases, Chronic
42 Obstructive Pulmonary Disease (COPD) is the most common indication for HOT worldwide.
43 Studies assessing the use of HOT to correct hypoxemia in COPD patients have demonstrated
44 many important benefits including increased survival, improved quality of life, and decreased
45 hospitalizations.^{1,2} It is estimated that of the 15 million patients in the United States that have
46 COPD, over 800,000 patients currently receive home oxygen therapy at an annual cost of 2.3
47 billion dollars per year.^{3,4}

48 While the efficacy of HOT is undisputed, medical providers continue to deliberate over
49 whether to offer HOT to known smokers. Most providers recognize that burn injuries
50 associated with home oxygen can cause serious and life-threatening risks to their patients, the
51 patient's cohabitants, and emergency responders. Unfortunately, up to 52% of patients who
52 use HOT continue to smoke in spite of these risks and their ongoing hypoxemia.⁵ While home
53 oxygen providers may counsel patients to avoid open flames and recommend signage attesting
54 to the presence of oxygen, patients may either forget these instructions or disregard them
55 altogether.

56 We conducted a retrospective review of burn injuries sustained from smoking on HOT
57 that were admitted to a regional burn center. Our goals were to better characterize the

58 morbidity of these injuries and determine if our incidence rates were comparable to previously
59 published data.

60 **Methods:**

61 This study was conducted with the approval of the Indiana University Institutional
62 Review Board. We conducted a retrospective review of admissions to our regional burn center
63 from 2008 through 2013. The Richard M. Fairbanks Burn Center at the Sidney and Lois Eskenazi
64 Hospital in Indianapolis, Indiana is the largest burn unit in the area, averaging 350 admissions
65 per year. From this burn unit database, we reviewed discharge diagnoses to identify 84
66 subjects admitted after injury involving smoking, cigarettes, or home oxygen therapy over the
67 6-year study period. We excluded individuals who sustained cigarette injuries unrelated to HOT
68 and those who experienced burns from home oxygen plus a source besides smoking (candles,
69 lighting a stove, grease fires). Over our six-year period we identified 55 subjects out of
70 approximately 2000 in the database with smoking related HOT burn injuries necessitating
71 admission.

72 Two authors working independently performed review of the included medical records
73 and cross-checked each other for accuracy and completeness. Demographic information,
74 oxygen prescription, location of injury including bystander presence, and medical comorbidities
75 were all recorded. Following identification, each subject was screened using the Indiana
76 Network for Patient Care⁶, a regional health information exchange tool, to look for evidence of
77 prior HOT related injury, substance abuse history, and smoking cessation counseling. To
78 evaluate the extent of each injury, we recorded the percent of total body surface area burned

79 (TBSA), locations of injury, need for intubation and presence of inhalation
80 injury was confirmed by notation of airway edema, soot and/ or erythema of the
81 tracheobronchial tree on bronchoscopic reports. We additionally analyzed the number of
82 operative procedures performed including tracheostomy for each subject following injury.
83 Total length of stay, length of intensive care unit (ICU) stay and number of ventilator days were
84 recorded. Finally, we noted the discharge disposition for each subject including mortality,
85 location, and ongoing prescription for HOT.

86 All information was recorded in a web-based Research Electronic Data Capture
87 (REDCap) database.⁷ Descriptive statistics were then used to characterize the population and
88 analyze and interpret our specified study metrics.

89 **Results:**

90 We identified 55 patients admitted over a six-year period from January, 2008 through
91 December, 2013. Our study population demographics are shown along with prescription flow
92 rates and comorbidities (Table 1). Most injuries (93%) occurred at home. In 24 patient
93 instances (44%) other adults were in the home at the time of the event. We found evidence of
94 children in the home in 3 cases. In five cases it was noted that the initial burn led to a house or
95 apartment fire.

96 Seventy-two percent of burns involved less than 5% TBSA. The majority of burns (87%)
97 involved the face and 11% involved the one or both hands. Twenty five patients underwent
98 bronchoscopy to evaluate for airway injury and 18 patients had injuries as described (Table 2).

99 Over half (51%) of the subjects required intubation for respiratory failure, nine subjects
100 required plastic surgical interventions, and four eventually required tracheostomy (Table 2).
101 Two subjects were living in an Extended Care Facility on admission and 29% were discharged to
102 a facility. Mortality was 14.5% and mean length of hospital stay was 8.6 days (median 5 days).
103 There were 43 survivors (78%) discharged with oxygen after the injury. Seven subjects (13%)
104 were noted to have documented evidence of counseling about smoking cessation and oxygen
105 use prior to combustion injury. Eight subjects (14.5%) were found to have a prior cigarette-HOT
106 related injury and a history of substance abuse was noted in the medical record in 27%.

107 **Discussion:**

108 Smoking remains an addictive habit for many of our patients. In our state, Indiana
109 U.S.A, the smoking rates are an astounding 24% for adults over age 18.⁸ These rates
110 demonstrate the addictive power of cigarettes as many people continue to smoke in spite of
111 the known risks of cardiovascular disease, COPD, and lung cancer. It may be no surprise that
112 many patients who are prescribed HOT for severe cardiopulmonary diseases continue to smoke
113 in spite of the burn risks as well. Our review of our burn database affirms the high morbidity
114 and mortality that can be seen with these injuries. Similar to other authors, we found these
115 patients to generally be older, have a higher rate of inhalation injury, and a longer
116 hospitalization despite smaller body surface area injuries.⁹

117 Interestingly, we discovered high rates of substance abuse history and previous smoking
118 related HOT injury among our study population. While we do not have demographic data of
119 our entire population to make definitive correlations, to our knowledge this association has not

120 been previously described and thus warrants more investigation. We speculate that individuals
121 who have a record of “throwing caution to the wind” may be more likely to attempt to smoke
122 while using home oxygen. Interestingly, in spite of the high prevalence of repeat injuries
123 (14.5%), we found that 78% of subjects were discharged with home oxygen and only 13% had
124 documented evidence of prior counseling regarding smoking cessation. Ongoing education and
125 very careful consideration regarding withholding home oxygen to substance abusers or prior
126 burn injured patients is called for. Given the effects carbon monoxide has on oxygen uptake,
127 carrying capacity, and tissue delivery we question the utility of home oxygen use in smoking
128 patients with hypoxemia. Further studies would help elucidate if the effects of smoking
129 mitigate any physiologic or clinical benefit from HOT in this population.

130 Despite relatively low percent BSA involvement (most subjects had 1-5% BSA burns)
131 HOT burn victims experience significant morbidity. (Table 2) Our findings are similar to
132 previous studies of burn patients injured while on HOT.^{6,9-11} It is not surprising that these
133 patients have a high morbidity in part because they already have a severe baseline disease
134 state (96% COPD) that renders them medically jeopardized. Perhaps in part due to their pre-
135 existing medical conditions, we found that 54.5% of our subjects were discharged with home
136 health or to a care facility. This is significant in that the majority of admissions came from
137 home (93%), indicating transition to a higher level of care on discharge. A 2008 study noted a
138 similar trend with 47% of their population requiring higher levels of care on discharge.¹¹ HOT
139 related burns lead not only to complex and expensive hospital stays but to increased health
140 care utilization after discharge as well.

141 Finally, over the six-year study period, there were eight deaths following admission to a
142 specialized burn unit. This 14.5% hospital mortality is higher than previous studies of similar
143 size.^{6, 10} All deaths involved withdrawal of life sustaining interventions including mechanical
144 ventilation due to catastrophic nature of the injury coupled with the underlying illnesses. All
145 deaths had documentation of over > 20% BSA involvement. In four of the deaths, the
146 combustion caused a house fire leading to more extensive injury and smoke inhalation.
147 Notably, in sixteen records we noted stories of collateral damage involving house fires, other
148 occupants in the household also injured by fire, and reports of children in the home at the time
149 of fire. Two patients caused fires in their assisted living facilities. We are not the first to
150 recognize the risk posed by smoking on HOT to healthcare workers. A recent review identified
151 that 9% of home-health aid visits were to residences with home oxygen of which 25% identified
152 as smokers.¹²

153 There are some limitations to our study. We only assessed patients that were admitted
154 and were not able to include patients treated in the Emergency Department for minor burns.
155 We also were not able to capture patients who died at the scene or patients that died in the
156 Emergency Department. We believe that inclusion of this data this would only serve to
157 increase the prevalence and perhaps morbidity of smoking related HOT burns. Another
158 limitation was our inability to discern oxygen dose in 12 patients. We suspect there is an
159 increased risk for HOT burn injuries as oxygen does increases but without knowing the actual
160 dose at the time of injury of the prevalence of each dose in our population we cannot reliably
161 make this assertion.

162 In conclusion, our findings suggest that smoking related home oxygen burn injuries
163 continue to be prevalent. We agree with our colleagues that further work is needed to better
164 characterize the magnitude of these potential risks and to inform the development of practice
165 guidelines that help clinicians make appropriate determinations about the safety and
166 effectiveness of home oxygen, particularly in known smokers.¹³ We believe that aggressive
167 educational and smoking cessation efforts should be employed in this population in an effort to
168 avoid the harmful effects of this explosive combination. As part of this effort, we would ask
169 that guidelines developed for COPD stress the dangers of smoking while on HOT. Currently, a
170 minority of international COPD guidelines state or stress the risk of fires associated with
171 smoking.¹⁴ With ongoing attention to this important issue we how our local experience helps
172 influence change.

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Tables

Table 1: Demographics, oxygen prescriptions, and comorbidities.

Age (mean)	40-84 (62)
Race (%)	
African-American	3 (5.5)
White	51 (92.7)
Asian	1 (1.8)
Sex (%)	
Female	24 (44)
Male	31 (56)
Reason for HOT (%)	
Emphysema	53 (96)
Asthma	4 (7)
Oxygen dose LPM (%)	
1	0
2	9 (20.9)
3	15 (34.9)
4	11 (25.6)
5	3 (7.0)
6	3 (7.0)
10	1 (2.3)
>10	1 (2.3)
Unknown	12 (21.8)
Comorbidities (%)	
DM	18 (32.7%)

CAD	17 (30.9)
CHF	13 (23.6)
Anemia	7 (12.7)
Pulmonary hypertension	6 (10.9)
Obesity	7 (12.7)
OSA	3 (5.5)
Cancer	4 (7.3)
Substance abuse	15 (27.3)

Table 2: Morbidity data and discharge disposition.

Intubated (%)	28 (51)
Ventilator days, median (range) , mean (SD)	1 (0-53) , 4.2 (8.5)
ICU days, median (range), mean (SD)	4 (1-53) , 7.4 (8.8)
Hospital LOS, median (range), mean (SD)	5 (1-53) , 8.6 (9.3)
Inhalation injury (%)	18 (32.7)
Sloughing	2 (3.6)
Soot	10 (18.1)
Edema	6 (10.9)
Erythema	8 (14.5)
Operations (%)	9 (16.3)
Autograft	8 (14.5)
Homograft	7 (12.7)
Debridement	7 (12.7)
Tracheostomy	4 (7.4)
Discharge disposition (%)	

Home	25 (45.5)
Home with services	6 (11)
Subacute rehab	8 (14.5)
LTAC	6 (11)
Acute rehab	2 (3.6)
Death	8 (14.5)

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