Reducing Fires and Burns from Smoking While Using Medical Oxygen

Abstract

There is a growing awareness of the incidence of fires due to the misuse of oxygen therapy equipment while smoking. Smoking is by far the leading cause of injuries and deaths in all home fires, whether or not home oxygen is in use. Several studies have revealed an increased incidence of burn injuries associated with home use of medical oxygen, and it is believed that the frequency of fires has been grossly underestimated. Clinicians, providers, manufacturers, and regulators of this equipment share the responsibility to reduce the number of burn injuries and deaths. Responses and recommendations appear to be ineffective because of the lack of communication and a knowledge deficit concerning oxygen fires, particularly the incidence of unreported thermal burns, the ease with which tubing is ignited while oxygen is flowing, and the characteristic burn pattern toward the oxygen supply. This paper discusses the causes of home medical oxygen fires, explains cannula burn patterns and firebreaks, and identifies potential cost-effective solutions.

The Dangers of Smoking

Ninety-five percent of chronic obstructive pulmonary disease (COPD) is caused by smoking, with most smokers eventually developing some degree of pulmonary impairment. COPD may occasionally occur in nonsmokers as a result of environmental factors such as dusts, chemicals, or air pollution; or genetic factors such as alpha-1 antitrypsin deficiency.[1] COPD is the most common reason for long-term oxygen therapy (LTOT) prescriptions.[2] An estimated 182 home fires in the United States (US) involve oxygen therapy equipment each year, resulting in 46 deaths. An additional 1190 thermal burns involving oxygen therapy equipment require treatment each year in emergency rooms, with nearly half resulting in hospital admissions, yet the majority are not reported to fire officials.[3] The National Fire Protection Association (NFPA) estimates that in the US, 30 percent of oxygen patients continue to smoke, with other sources estimating smoking rates up to 50 percent.[4, 5] Smoking while on oxygen therapy is responsible for the majority of home oxygen fires and resulting deaths.[3] These incidents involve fire department interaction and are well documented. However, an alarming number of thermal burns in the US caused by patient smoking while using home medical oxygen occur each year that are not reported to fire authorities. It is feared that this number may be greatly underestimated, and will increase as the 50- to 75-year-old population grows, along with their need for oxygen therapy equipment.[3, 4]

Oxygen patients have been observed smoking while using their oxygen therapy, and self-report having engaged in this risky behavior repeatedly. Cannula ignition may occur during the initial lighting of the cigarette, bringing the cigarette too close to the cannula tips and having it flare up, or through the relighting of cigarettes, which may be more common now with the expanded use of self-extinguishing cigarettes.

Smoking while using oxygen therapy greatly increases the risk of facial burns. Facial burns account for 89% of all thermal burns, and although the overall burn size is generally small, due to the intense heat of the flame and inhalation of hot toxic smoke, significant injuries may occur to the patient's upper and lower airways that require hospital admission, specialized treatment at burn centers, or even result in death. At least a thousand burn injuries a year happen when cannula tips ignite after coming in close contact with cigarettes, lighters, or matches. In many cases, patients quickly remove the cannula and extinguish the fire, and fire authorities are never notified by the patient or hospital. Oxygen patients may be reluctant to report these occurrences due to embarrassment, or they may not want to take responsibility for the incident, since they were likely informed of the fire danger.

Consequences of these fires can be catastrophic for home oxygen patients, since their health is often already so fragile that even small burn injuries can have very poor outcomes. The disease processes that necessitate oxygen therapy can contribute to mortality from burns that would have been expected to be easily survivable in younger, healthier patients.[4] These patients differ from standard burn patients because they are older, have higher rates of inhalation injury, and require much longer hospitalizations, despite their injuries having a mean total body surface area (TBSA) of only 3 percent .[6] Mortality rates attributed to home oxygen fires may be understated for these compromised patients. Many times these related deaths are assigned natural causes, when in fact, the exacerbation was triggered by the fire injury. Some experts, particularly the Thoracic Society of Australia and New Zealand, feel that the risk of fire for patients who continue to smoke cigarettes while using oxygen therapy offsets the treatment benefits.[7]

Patients may choose to remove the cannula and place it next to them while they smoke. This creates an oxygen-enriched environment, particularly closest to the cannula tips, of bedding and other combustible materials that can create a flash-fire with just an ember. While oxygen itself does not burn, it greatly lowers the ignition point of combustible materials.

Most fire deaths in the bedroom occur as a result of smoke inhalation while sleeping, whether oxygen is involved or not. Smoking in bed increases the probability of falling asleep, greatly increasing the likelihood of the cigarette touching and igniting the bedding or oxygen tubing. In addition to sleeping, many victims of fires caused by smoking materials are affected by alcohol, drug impairment, or a health condition that limits mobility, cognitive function, or the ability to react prior to the fire. Impairment is much more likely with smoking material fires than with other fires.

The percentage of alcohol involvement among fatal victims was 23 percent for smoking material home fires in 2004-2008, compared to 11 percent for all other home structure

fires with a known heat source as the cause of ignition. The percentage with possible other drug impairment during the same time period was 10 percent for smoking material home fires, compared to 4 percent for all other home structure fires with a known heat ignition source. Sadly, in two-thirds of all home fire deaths, smoke alarms are either absent or not working.[3] Anything that causes a delay in reaction time will decrease survival rates.

Cannula tubing burn pattern: back to the oxygen source

Oxygen cannula and tubing made of polyvinyl chloride (PVC) is commonly used to administer oxygen therapy. A cannula refers to a patient interface, which has two vinyl tips, or prongs, for positioning at the base of the nostrils, and attaches to tubing of lengths up to 50 feet (15.2 m). Most homecare companies use cannulas of 4 or 7 feet (1.2 or 2.1 m), and supply ample lengths of additional oxygen tubing in the range of 25 to 50 feet (7.6 to 15.2 m). This allows a patient to move about freely within the home and away from the oxygen supply, which may be heavy and difficult to move. The oxygen equipment may be located in a central position of the home, such as a hallway, living room, bedroom, or even on a different floor or level. Tubing is commonly gathered and coiled up to prevent tripping and clutter while it rests on the floor, as one does with a long extension cord. When a patient moves around the home, the position of the tubing changes and touches combustible materials, such as carpeting, bedding, furniture, curtains, and clothes.

Although the cannula does not easily ignite in room air or with a pulsing oxygen conserving delivery system, when a continuous flow of oxygen passes through it, the cannula tips and tubing will easily ignite when in close proximity to any flame or ember. The nasal cannula tubing, a PVC product, emits an intense flame and thick, toxic black smoke when burning, releasing highly flammable vinyl chloride gas.[5] Although referred to as a cannula fire, a more accurate description is cannula torch or fuse, because of its intense flame and the speed at which it supplies ignition to combustibles as the fire advances up the tubing towards the oxygen supply.

Any portion of the cannula and tubing may ignite from a flame or cigarette ember, and the point of ignition is generally very recognizable, as it presents a delineation between the burned and intact tubing. This flame can travel both externally or internally down the tubing, giving off a loud whistling sound. Once ignited, the fire consumes the tubing, leaving a charred trail of ash and melted tubing as it advances, always toward the oxygen supply.[8] A 4 foot (1.2 m) Salter 1600-4 cannula ignited at the tips takes about 2.5 minutes with a flow rate of 2 liters per minute (LPM), 4.5 minutes with a flow of 3 LPM, and 10 minutes at a flow rate of 5 LPM to burn to the connection. Although, burn times seem counter intuitive for each liter flow listed, results were validated. Higher oxygen flows create a slower moving, more intense fire as it burns back to the oxygen source. As the tubing burns, combustible materials ignite along its path, creating additional fires. The fire may bypass and jump sections of crossed or coiled tubing and continue burning toward the oxygen supply. The tubing may also whip around (in a manner similar to a full flowing, unattended garden hose), fanning its reach to ignite combustibles.

If a humidifier bottle is used, it also will readily burn, and may cause additional damage to the device and allow the fire to breach the cabinet, depending on its location. Gathered or coiled oxygen tubing on and around the oxygen supply, particularly an oxygen concentrator, may cause the cabinet of the concentrator to ignite, sustain heavy damage, or even become unrecognizable.

The most common medical oxygen supplied for use in the home is an oxygen concentrator, a machine that separates room air and concentrates the oxygen. A trail of burned tubing outside and downstream of the machine is evidence of oxygen flowing within the tubing and an external ignition source, as fire always advances toward, rather than away from, the oxygen supply. In fact, when PVC tubing was ignited by a fire investigator, it stopped burning within 20 seconds of shutting off power to the oxygen concentrator.[8] Concentrators damaged by fire may incorrectly be identified as the ignition source when this burned tubing is observed by people who are not aware of this specific burn pattern. This may create an erroneous belief that oxygen concentrators are unsafe, when these electromechanical devices do not store oxygen, cannot explode, and stop functioning when fire enters the device. In the rare event that the concentrator is the ignition source, there will be no evidence of burnt tubing leading up to the machine.

The cause of the fire is frequently misrepresented by grieving family members, but sometimes even experienced fire investigators get it wrong. A malfunctioning oxygen machine was initially believed to be the cause of a tragic blaze that killed four children and an elderly grandmother on LTOT because the machine was found melted in the rubble, and the family reported it to be the ignition source.[9] Later investigation revealed that the family had attempted to move a burning couch outside, but could not get it out the door, and it is now believed that the fire started when the patient was smoking while using her oxygen on the couch.[10] Another grieving family is blaming their loved one's death on an exploding oxygen concentrator, even though her death certificate states that the cannula, the tube which delivers oxygen into the nostrils, ignited.[11] Additionally, in both of these fires, as well as all others, the fire advanced toward the oxygen supply, not away from it, and oxygen flow is needed within the cannula to produce its characteristic burn pattern, providing evidence that the machine was not the starting point.

An even greater hazard is present during fire with liquid oxygen canisters or compressed oxygen gas cylinders. Unlike oxygen concentrators, these oxygen containers may rupture or explode, releasing large quantities of oxygen contents into the room, increasing the rate of combustion, generating more heat, and even causing fragments of the tanks to become projectiles. A recent mobile home fire in Florida caused oxygen tanks to explode, accelerating the fire as well as the danger to firefighters.[12] Two fatal fires caused by LTOT patients smoking in Pitt County, North Carolina, became significantly more dangerous for victims and rescuers when oxygen tanks exploded. Both patients died in the separate incidents nine hours apart, and three firefighters were injured.[13] In yet another incident in Florida, two firefighters and a neighbor were injured in a mobile home fire that ignited medical oxygen tanks, throwing one of the rescuers 15 feet (4.6 m) in the blast.[14] Another explosion during a fatal fire in Washington caused fragments of the pressurized tanks to hit firefighters as they attempted to reach the victim, who had started the blaze by smoking while using medical oxygen.[15]

Firebreaks

Firebreaks are considered secondary prevention measures, as are smoke alarms and fire extinguishers, because they do not prevent fires, but attempt to reduce negative consequences. Firebreaks are devices designed to stop the flow of oxygen along the oxygen supply tubing, preventing the spread of fire past their location. They are used as connectors in the oxygen supply line or at the oxygen source, incorporating a small piece of plastic that holds open a spring-loaded metal ball. When the fire reaches the plastic, it melts, allowing the spring to push the ball shut, stopping the flow of oxygen. They may be installed between the cannula and the oxygen supply tubing and at the oxygen source. They are promoted to provide additional time for evacuation, to prevent the spread of fire upstream to the equipment, and to reduce the probability that the fire will spread further.

While some agency and home care equipment providers view firebreaks as a cost-effective way of improving patient safety, others share an unfavorable view, noting them as only a secondary measure that does not address behavior modification needed to lessen the high occurrence of thermal burns to the face. Others are concerned that firebreaks may send the wrong message to patients: that is smoking while on oxygen therapy is in some way "safer" with the use of these devices. Unfortunately, many incidences of fires and burns while using oxygen therapy remain undocumented, making it difficult to accurately report incidences and properly credit the potentially effective measures. In the United Kingdom (UK), where firebreak use has been required since 2005, a joint working group of oxygen suppliers, Fire and Rescue Services, and health care agencies have undertaken initiatives to raise awareness of the dangers of smoking while using oxygen.[16, 17] Unfortunately, according to the Department of Health, the collated smoking-related oxygen fire incidents results are alarming: There were 106 smoking-related fires in the period from April 2010 – March 2011.[18]

In considering the use of firebreaks, it is important to consider their placement in the oxygen cannula and tubing, as well as their limitations.

Placement

A firebreak's effectiveness in reducing fire potential is directly related to its proximity to the ignition point.

In the UK, home oxygen installation is rather unique. A house is piped with safety tubing affixed to the wall, with two or more outlets where the cannula is attached. The National Health Service (NHS) Home Oxygen Service Specification (2005)[19] has a requirement for firebreaks. Although not detailed in the requirement, it is largely accepted that firebreaks need to be placed as close to the patient as possible. Other agencies and standards require oxygen concentrators to be fitted with a means of preventing fire from entering the machine.[20] Therefore, there needs to be at least two firebreaks: one close to the patient and another at the oxygen supply. Since humidifiers are highly flammable

with oxygen flow, a firebreak would also be needed at this spot, amounting to three firebreaks per installation.

The overwhelming majority of home oxygen fires are started by the patient at the cannula.[3] Currently, there is no firebreak device on the market that fits into the most common point of ignition: the ends of the cannula prongs.

Inner channels are incorporated in most cannulas and tubing as a safety feature, which prevents oxygen flow from occluding when tubing is kinked. These channels prevent the splicing of oxygen tubing to accommodate the firebreak; consequently, the closest opportunity to install a firebreak is at the cannula and its oxygen tubing connection.

Common cannula lengths are four and seven feet (1.2 and 2.1 m), with a seldom used one foot (.3 m) cannula available. The cannula is added to one or more 25 foot (7.6 m) sections of oxygen tubing. While it appears that a shorter length cannula would be safer, a firebreak connected to a one-foot cannula would be easily bypassed by a cigarette dangling from the outstretched arm of a sleeping patient, creating the deadliest of all scenarios.

A firebreak located close to, or at, the oxygen supply has minimal benefit. A fire reaching this point has traveled the length of the tubing, already creating serious damage. There is an elevated risk when gas and liquid oxygen cylinders and canisters are involved: large quantities of oxygen may be released, or the cylinder may rupture or explode with the intense heat of a fire. An oxygen concentrator does not present this danger, as it will stop functioning when fire enters the unit.

Limitations

Firebreaks do not reduce the occurrence of fires or awaken individuals in the event of the deadliest of fires: falling asleep in bed while smoking.

Firebreaks do not extinguish fires. Even if the cannula tubing is no longer burning, combustible items such as clothing, bedding, carpeting, curtains, or furniture already ignited will continue to burn.

Burning cannula tubing, even just a small length, produces large amounts of thick noxious smoke, which injure and overcome patients very quickly, even when firebreaks are in use.

Firebreaks only stop the flow at their position; secondary fires may reignite the oxygen tubing.

Fire can jump sections of coiled tubing and bypass the firebreak.

Firebreaks are directional and may be inserted the wrong way by patients.

Firebreaks create back pressure, resulting in reduced oxygen delivery when using orifice flow controllers, or reduced sensitivity and performance when using oxygen conserving devices. If devices deliver both continuous flow and pulse flow delivery, the firebreak may need to be removed during the pulse flow delivery mode.

Firebreaks built into oxygen concentrators or added to their outlets do not address the humidifiers when used.

Firebreaks only limit fire potential; requirement mandates would add substantial cost without evidence of effectiveness. Of the 1190 thermal burns annually, 1059, or 89 percent, burn the face of the patient. Patients who smoke and set themselves on fire at the cannula pull it off quickly and extinguish the fire. It is unlikely that fire breaks will reduce this type of fire injury or resulting death, since the fire begins proximal to its placement in the tubing.

Effective Solutions for Reducing Fires, Burns, and Deaths While Using Oxygen

The most important solution is a coordinated effort to highlight and stress the dangers of smoking while on oxygen therapy through aggressive patient and caregiver warnings and education by prescribing clinicians and equipment providers.[5]

Smoking cessation is the safest way to reduce the incidence of home oxygen fires. However, this may not be a realistic goal for all, as an estimated 30–50 percent of these patients continue to smoke. Many are unable or unwilling to quit at this point in their lives, after decades of smoking. Nicotine addiction is a chronic, relapsing disease, and less than 3 percent of attempts to quit result in sustained, 12-month cessation.[21] LTOT patients who smoke must be offered smoking cessation interventions such as nicotine replacement therapy to prevent nicotine withdrawal.[22]

If patients are going to continue to smoke, it is imperative that they understand the importance of turning off the oxygen, removing their cannula, and leaving the room where their oxygen was in use. These three precautions, in addition to thoroughly explaining the dangers of smoking with oxygen therapy equipment, need to be clearly stated and presented separately from the accompanying user manual. The majority of LTOT patients are elderly, and many have impaired vision, lower reading levels, and even different primary languages. Brochures and educational materials need to include pictures that perhaps realistically depict the results of a cannula fire with facial burns, as this is a very real possibility for patients who smoke while using their oxygen. Educational DVDs should be produced and widely distributed.[23, 24]

The prescribing clinician needs to be responsible for discussing and documenting education about the hazards of smoking during oxygen therapy at the initiation of LTOT,

and for reviewing this information every six months, or more frequently if a close encounter is reported that is related to smoking.

A signed checklist and agreement to comply with smoking safety guidelines should be completed by the HME provider, and any witnessed violations of safety guidelines, such as smoking while oxygen is in use, should be reported to the prescribing clinician within 48 hours.[25]

Repetition is an effective way to reinforce safety messages. The US Food and Drug Administration (FDA) requires large, graphic warnings about the dangers of smoking on every package of cigarettes,[26] not on the bottom of ashtrays. In the same way, nasal cannulas are disposable items used with all oxygen systems, and require regular replacement. Their user instructions present the best opportunity for a repetitive, highly visual safety message. FDA involvement would be required to implement this intervention.

Clinicians and providers are morally and ethically obligated to fully inform patients and their families of the risks and benefits of oxygen therapy. However, should the patient choose to continue to smoke without taking the necessary precautions, the risk of unsafe oxygen use may lead to a difficult decision of equipment removal, or at the very least, exchanging continuous flow delivery with a pulse-only system.

Conclusion

Regulating agencies, home` care providers, manufacturers, and health care providers who prescribe oxygen equipment must all share the responsibility of formulating and recommending effective strategies to reduce the incidence of fires involving home oxygen equipment. These strategies must be effectively communicated to our patients and caregivers. It is dramatic to witness how easily and violently a nasal cannula burns. Perhaps if those who are setting up equipment and taking care of LTOT patients have viewed footage of how these materials ignite and burn, as well as the resulting injury and damage it creates, then this danger would be more thoroughly and emphatically explained to patients and caregivers.

The use of oxygen while smoking is product misuse with deadly consequences. This warrants patient behavior modification through primary prevention measures: education and instruction. Primary prevention is always preferable to secondary prevention when dealing with the health of patients. Education is the key to reducing the impact of unsafe choices and the incidence of fires as a result of this risky behavior. Secondary prevention measures, such as smoke alarms, fire extinguishers and firebreaks are intended to identify and treat fires early that have already occurred, but do nothing to prevent them or reduce the number of occurrences.

Oxygen equipment includes warnings about the dangers of smoking in their user manuals, and the devices are marked with symbols prohibiting smoking; yet, there is no warning on the oxygen cannula. While the industry’s objective is no smoking, the reality

is that up to 50 percent of LTOT patients continue to smoke. Although patients may have a right to continue to smoke, it is imperative that they turn the oxygen off, remove their cannula, and leave the room where their oxygen was in use.

Smoking is the number one cause of death in home fires for all households in the United States, and 7 percent of the estimated 680 home fire deaths per year are related to the use of oxygen therapy equipment. For the two million households that use home oxygen, there is the added hazard of high concentration oxygen. While the size of the oxygen-enriched environment created by an oxygen concentrator in and around the patient is debatable, what happens when patients bring their cigarette too close to the cannula is irrefutable. Oxygen is not flammable, but it converts cannulas and oxygen tubing into easily ignited fuses set off by cigarettes causing potentially deadly situations for patients and their families. Most of these injuries and deaths are preventable through proper education and instruction.

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Addendum A

Patient Handout – Separate instructions which include the message that patients must turn off the oxygen, take off the cannula, and leave the room before using smoking materials. (This should include similar graphic images to those contained in the medical safety information sheet - link provided below.)[27]

http://www.pmda.go.jp/english/service/pdf/safety/No4.pdf

Addendum B

Delivery/Safety Checklist

Home Oxygen Hazard Awareness Safety Agreement

- "No Smoking, Oxygen in Use" signs are provided/posted.
- Smoke alarm is present and patient agrees to test alarms monthly.
- Patient has been reminded not to smoke while using oxygen.
- If unable or unwilling to stop smoking, patient has been instructed/reminded to remove the cannula, shut off the oxygen supply, and leave the room, or if unable/unwilling to leave the room, wait for 10 minutes for oxygen to dissipate prior to smoking.

HME Representative Signature:

_____ Date: _____

I agree to comply with the above safety guidelines:

Patient signature:

_____ Date: _____

If risky behavior is observed, such as smoking in proximity to oxygen equipment by anyone, or absent smoke alarms, this form will be signed and faxed to prescribing clinician within 48 hours.

Addendum C

Prescriber/Educational Checklist

Home Oxygen Hazard Awareness Safety Agreement[5, 22]

Safety Tips

- Never smoke in a room where oxygen is used.
- Post "no smoking" signs in and outside of the room to remind residents and guests not to smoke.
- Smoking cessation is strongly suggested: cessation aides will be prescribed or recommended.
- If unable or unwilling to stop smoking, patient has been instructed/reminded to remove the cannula, shut off the oxygen supply, and leave the room, or if unable/unwilling to leave the room due to physical limitations or inclement weather, wait for 10 minutes for oxygen to dissipate prior to smoking.
- Do not smoke in bed, if sleepy, or if under the influence of alcohol or medications, as this increases the risk of accidental fire.
- If oxygen is used in the home, the amount of oxygen in the air, furniture, clothing, hair, and bedding may increase, making it easier for a fire to start and spread. This means that there is a higher risk of both fires and burns.
- Never put a cannula in bedding to smoke …you might think it is off when it is not and oxygen still may bleed out.
- Do not use petroleum or flammable products on the skin and hair, especially on the face, head and hands, where they may be in close proximity to the cannula tip.
- Never use an open flame, such as candles, incense, matches, wood stoves, and sparking toys, within 5 feet (1.5 m) of the oxygen source, tubing and accessories.
- Make sure that the home has smoke alarms and test them at least monthly.
- Have a fire extinguisher available in the home.
- Have a home fire escape plan with two ways out of every room and an outside meeting place, and practice the plan at least twice a year.
- People who may have difficulty escaping a fire should have a phone near their bed or chair.

Prescribing Clinician Signature: _____ Date: _____

I agree to comply with the above safety guidelines:

Patient Signature: _____ Date: _____

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