Appendix 3 - Non-airway burns/fires in the operating room

Purpose

To guide anaesthetists, operating room staff and surgeons in preventing and managing non-airway non-intrathoracic fires in the operating room.

Scope

This appendix applies to preventing and managing patient-related non-airway burns/fires associated with the use of supplemental oxygen in the operating room.

Definitions

Non-airway burns/fires occur outside the airway and do not involve airway surgery.

Background

Fires in the operating room are relatively rare; however, they pose a significant threat to patient and staff safety and can result in severe injuries or even fatalities. In addition, fires might spread beyond the immediate area and require the evacuation of the operating room or even the hospital [1]. In the American Society of Anesthesiologists (ASA) Closed Claims Database, up until 2013, 103 OR fires accounted for 1.9% of the total surgical claims and typically occurred in older patients [2]. It is estimated that there are 88-650 cases per year [3,4] in the United States, with an incidence of 0.2-0.8 surgical fires per 100,000 surgical procedures [5].

The local webAIRS reporting system [6] showed the most frequent thermal injuries were observed in the head and neck areas during superficial surgical procedures performed under monitored anaesthesia care, specifically in the fields of plastic surgery, vascular surgery, and cardiology. These injuries represented 50% of the total thermal injuries reported. Ten cases were linked to using an open system to deliver supplemental oxygen, harming the patient's face and airway. This harm included six superficial burns, accounting for 60% of the injuries, two partial-thickness burns, making up 20%, and two inhalational injuries, also at 20%. Various oxygen delivery devices were involved in these incidents, such as simple face masks (50%), low-flow nasal prongs (10%), and high-flow nasal prong devices with humidification (40%). The concentration of oxygen provided by these devices varied, with FiO2 levels ranging from approximately 30% to 100% and flow rates from 3L/min to as high as 70L/min.

These fires typically involve the ignition of flammable substances, such as surgical drapes, alcohol-based skin preparations, or even the patient's body tissues in an oxygen-enriched atmosphere.

The fire triangle or triad [7,8] is a concept used to illustrate the three elements that are necessary for a fire to occur: fuel, an oxidiser (typically oxygen), and an ignition source.

1. Fuel: Fuel refers to any material that can burn. It can be a solid, liquid, or gas. Common examples of fuel in the operating room include surgical drapes, alcohol-based skin preparations, flammable gases such as methane (e.g. in the patient’s bowel), and other flammable substances such as clothing or hair [9].

2. Oxidiser: This supports the chemical reactions that occur during a fire, with oxygen being the most common oxidiser, followed by nitrous oxide. In the medical setting, supplemental oxygen is used, leading to oxidised-enriched atmospheres, which can significantly increase the risk and hasten [10-12] the intensity of fires, especially as concentrations increase [10,13,14]. Fires may occur with an open delivery system during monitored anaesthetic care in the head, neck and upper chest surgical fields [2,15].

3. Ignition Source: An ignition source is any heat source capable of raising the temperature of the fuel to its ignition point. The most common ignition source is the monopolar diathermy attached to an

electrosurgery unit. Still, it can also include any heat-generating device such as a bipolar diathermy [2], lasers, fibre optic light sources, drills or, occasionally, a cardiac defibrillator.

Prevalence and risk factors:

Certain procedures carry a higher risk of fires, such as those involving head, neck, or upper chest surgeries [2,5]. These include plastic surgery on the face (64%), miscellaneous neck procedures (12%), temporal artery biopsy (8%), upper chest procedures such as a pacemaker or central line insertion (6%), and carotid endarterectomy under local and sedation (3%) [2].

Factors that increase the likelihood of fire include the presence of an open oxygen source with a higher proportion in nasal cannula oxygen administration [2], which produced greater than expected oxygen concentration, especially at higher flow rates [16-18] or dislodgement of the cannula [19], the concentration of the oxidiser in the immediate area [11] especially if greater than a FiO2 of 0.3 [20], the use of flammable materials or facial hair or eyebrows [9], the proximity of the ignition source to the fuel, and inadequate communication by the operating room team [2].

It should be noted in a small ophthalmic plastic study sampling oxygen concentration around the eyes that a correctly fitted nasal cannula resulted in no oxygen-rich environment compared with an oxygen-rich environment (24.3 - 33.8% average oxygen concentrations) when facemasks were used. However, no flow rate is mentioned [21]. Furthermore, another study showed that at a flow of 2 l/min, oxygen concentrations exceeded 23% only within a few centimetres of the nasal cannula and that concentration increased as a flow function [17]. It was recommended that all ignition sources should be kept at least 10 cm away from the oxygen source when using flow rates greater than 4 l/min with a nasal cannula or restricting the oxygen flow to less than 3 l/min. However, a surgical fire occurred when a patient received oxygen administered via a single nasal sponge cannula at low flow (2 l/min), albeit after monopolar diathermy was applied [22].

Christiana Fire Risk Assessment Score System [23]

This is a rapidly performed simple 3-point scoring system developed to identify operations at increased risk of surgical fires and to heighten awareness around prevention, which should ideally be performed during the time-out process.

Surgery above the xiphoid:	1 point
Open oxygen source:	1 point
Available ignition source	1 point

Total Points	
Low risk for a surgical fire	1 point
Medium risk for a surgical fire	2 points
High risk for a surgical fire	3 points

Prevention

Preventing fires in the operating room involves implementing robust safety protocols. These measures include conducting thorough fire risk assessments, ensuring proper communication and coordination among the surgical team, maintaining a clutter-free environment, and using non-flammable surgical drapes and equipment whenever possible. Additionally, carefully administering supplemental oxygen and properly handling flammable substances are crucial in reducing the risk of fires.

1. Shared decision-making and communication:
    - Effective communication and shared decision-making between anaesthetists, surgeons, and nursing staff are crucial to minimise the risk of surgical fires.
    - The risk factors for fires, including oxygen concentration, ignition sources, and available fuel, should be addressed in pre-operative discussions.
    - This conversation should emphasise the importance of safety and the optimisation or discontinuation of supplementary oxygen delivery throughout the various stages of the surgical procedure.

2. Institutional considerations.

- Communication regarding fire risk levels should be discussed at the beginning of the list or time-out process, and a strategy should be implemented to prevent or reduce the risk of it happening: refer to Communicating for Safety Standard.
- Designated Staff should be trained in the selection and use of fire extinguishers.
- Fire and Evacuation policies
- Equipment availability
- Structural safety to minimise risks:
    i. Fire extinguisher availability and location
    ii. Fire blanket availability and location
    iii. Automatic Sprinkler and misting systems
    iv. Low-level lighting
    v. Access to fire safety equipment
    vi. Fire Smoke and Audio alarms
    vii. Signage
    viii. ISO Australian Health Safety Guidelines
    ix. Certification of fire safety
    x. Ensuring evacuation routes are kept clear.
    xi. Communication with Fire Services
    xii. Operating theatres are designed so that most operating theatres remain unaffected by fire should one occur, and they should be separated by a 30-minute fire-rated sub-compartment [1].
    xiii. Evacuation boxes

The National Construction Code Volume One Building Code of Australia 2022 defines hospitals as Class 9a buildings where occupants require assistance to be evacuated. The performance-based design brief is prepared by consultation between a fire safety engineer, architect, fire service, appropriate authority, client, and tenants. It is the plan that specifies what is required. The appropriate number and locations for fire hose reels and hydrants to cover the whole building, as well as fire extinguishers that cover Class A (flammable materials) and E (Electrical) fires, should be available. Typical in the operating area, this is a CO_2 one, which should be tested every six months and recharged every five years.

3. Anaesthetic considerations.
    - Supplemental oxygen should only be administered when indicated and at the lowest necessary dose to maintain patient oxygenation after the local anaesthesia has been infiltrated.
    - If supplemental oxygen is required, consideration should be given to intermittent oxygen administration when diathermy is not in use, and the diathermy time should possibly be limited if the patient's oxygenation is not maintained with this method. However, it might be better to use a closed system administration if oxygenation is not maintained.
    - If concerned about fire risk, use a closed system with a cuffed endotracheal tube or a partially closed system with a supraglottic airway. Consider securing the airway with a supraglottic airway or with tracheal intubation if there are concerns about fire risk and for procedures above the xiphoid or if >30% oxygen is used.
    - Ongoing high-flow nasal oxygen (HFNO) is not recommended during local and sedation procedures in the head and neck region involving an ignition source (diathermy), and the minimum amount of oxygen supplementation required to keep the patient's oxygen saturation at a reasonable level is the aim [24]. If necessary, an oxygen air blender can be used if the oxygen concentration required is less than 30%. If a higher concentration is required, consider securing the airway.
        i. Specifically, Fisher and Paykel Healthcare provide the following advice regarding their high-flow nasal oxygen system to avoid fire and burns: From their FIRE DANGER information [25].
            - This product is an open oxygen delivery system.
            - Open oxygen delivery can increase the risk of a surgical fire occurring, causing serious injury or death. Extreme care must be taken.
            - **Contraindicatio**n: Do not use this product with electrosurgery or electrocautery devices on the head or neck.
            - **Warning**: Do not use this product where ignition sources and fuel are present.

- One small study of 10 people showed that the ambient airway rapidly dilutes HFNO-administered oxygen and does not cause an increased oxygen-enriched environment around the chest [26]. However, this should be interpreted cautiously, as a chest fire in the setting of HFNO has been reported (personal communication).

4. Surgical considerations.
    - Ideally, do not use an ignition source (diathermy) near supplementary oxygen.
    - Single operator diathermy use [27].
    - Utilising the lowest effective power [27].
    - minimising time in cutting mode (cutting mode generates higher temperatures than coagulation mode) [27],
    - using bipolar diathermy rather than monopolar (whilst this does not obliterate the risk of ignition entirely, there is less current leakage with bipolar; therefore, it is preferable) [27]
    - Keep diathermy in a sheath when not in use.
    - To prevent oxygen pooling, it is important to ensure properly configured surgical drapes and avoid leaving any space where oxygen can accumulate, as oxygen, being heavier than air, tends to pool beneath the drapes. [11,27,28].
    - Consider draping the surgical field with wet, saline-soaked packs or ensure that wet packs and saline are available to help extinguish a fire.
    - If surgery is close to the oxygen source, consider 'open' draping or placing a plastic barrier apron on patients to prevent oxygen enrichment in clothing and bedding [29]. However, occlusive drapes (e.g. for ophthalmic surgery) may be falsely reassuring as they may still have gaps that allow oxygen to travel to the proximity of the surgical site [30].
    - Consider using a scavenger system to prevent excessive pooling of oxygen near the surgical site [31].
    - Minimise burn eschar [28].
    - Fire retardant surgical drapes [32]
    - Consider avoiding alcohol preparations [32-35] for superficial procedures by using an antiseptic solution such as povidone-iodine solution or aqueous chlorhexidine instead. If an alcohol preparation is indicated, use minimal amounts, avoid pooling of the alcohol preparation, and allow at least 3 minutes of time to dry so the alcohol can evaporate [28]. However, this doesn't guarantee that a fire will not happen [35], and longer may be required in people with a lot of hair. There should be an assessment before starting the operation for the pooling of the prep solution [35].

Management of a non-airway fire/burn

Despite preventative measures, fires can still occur in the operating room. Immediate and effective response is critical to minimising harm. The operating team should be trained in fire response protocols, including stopping the procedure, removing the ignition source, and extinguishing the fire with fire extinguishing agents designated for the purpose, providing it is safe. Patient and Staff safety and evacuation take precedence over extinguishing the fire if it is not small, controllable, and self-contained. Be aware that flame from ongoing combustion (especially alcohol) may be hard to see in a brightly lit operating theatre.

1. Immediate [36]
    - Stop diathermy.
    - Stop additional oxygen supplementation to reduce FiO2 to 0.21
    - Call for help.
    - Remove drapes and burning material.
    - Flood the fire with saline or saline-soaked gauze and then institute a cutaneous burn treatment with cold running water for at least 20 minutes within the first 3 hours [37]. If this is unrealistic (eg on the face), then regularly changed wet packs should be applied.
    - Use a carbon dioxide fire extinguisher.
    - Consider closing the oxygen shut-off valves and evacuation plans if the fire is ongoing.

    Alternatively, use:

    RACE Principles

R Remove/Rescue

Remove drapes and burning material or rescue any people in immediate danger only if it is safe to do so.

A Alarm/Alert

Raise the alarm, notify your switchboard and the staff member in charge or fire warden to escalate referral to fire service as required.

C Contain

If practicable, close all doors and windows to contain the fire.

E Extinguish/Evacuate

Try to extinguish the fire using firefighting equipment, but only if you are trained and it is safe to do so. Otherwise, evacuate if uncontrolled.

2. Ongoing patient management
    - Stabilisation – Re-establish ventilation, minimising oxygen and avoiding nitrous oxide. Assess the damage and consider inhalational injuries and whether intubation is required for ongoing management [36].
    - Referral
    - Transfer
    - Open Disclosure

3. Review
    - Fire compartments/oxygen shut-off valves for the specific areas.
    - Evacuation plans (should include laminated action cards suitable for the local environment)

Open disclosure

Open disclosure in the healthcare context involves how clinicians communicate with and support patients, their families, and caregivers who have experienced harm during their healthcare journey.

In Australia, the Australian Charter of Healthcare Rights and in New Zealand, Health & Disability Commissioner Te Toihau Hauora, Hauatanga, outlines patients' specific rights during the open disclosure process.

These rights empower patients to actively participate in their healthcare, ensure transparency and accountability within the healthcare system, and promote a culture of continuous improvement in patient safety and quality of care.

Awareness and education

Continuous education and awareness programs ensure that healthcare professionals remain vigilant about fire risks in the operating room. These programs should emphasise the potential hazards, preventive measures, proper response protocols, and the importance of teamwork during fire emergencies.

Practical in-house training programs [38], including the locations of fire extinguishers, oxygen shut-off valves, fire call points and evacuation plans, should be included in the orientation and ongoing education of staff, ideally in a multi-disciplinary setting [1]. This should occur on an annual basis for regular full-time staff.

Summary of Key Points for Fire Safety in Sedation and Surgery around the Face, Head, or Neck [7,39]

1. **Plan**: The anaesthetist and surgeon need to consider and discuss the level of sedation and the patient's oxygen requirements for the proposed procedure.

2. **Brief**: Appraise and discuss the plan and potential for risks (including using a risk assessment tool eg Christiana (above)) with the whole team. This includes confirming that all understand the institution's fire management protocol before commencing the operating list.

3. **Select** the appropriate oxygen delivery system (see also attached algorithm):
    a. For moderate or deep sedation or oxygen-dependent patients, consider using a closed or partial closed system (cuffed tracheal tube or supraglottic airway)
    b. For light sedation, an open system such as a facemask or nasal cannula may be suitable, though HFNO should be used with great caution, and a closed system may be a better option than HFNO.
        i. It should be noted that the oxygen concentration increases as the flow rate increases. Therefore, the flow rates should ideally be below 3 l/min, and if using more than 4 l/min, the operation should be greater than 10 cm away [17], or a closed system should be considered.
        ii. There is conflicting evidence about whether a facemask or nasal cannula is a safer option. More airway fires in the US occurred with a nasal cannula [2]. However, in oculoplastic practice, a correctly fitted nasal cannula resulted in lower oxygen concentrations than the facemask around the eyes [21], and a flow rate was not mentioned.

4. **Alert**: The surgeon should inform the anaesthetist in advance before activating any ignition sources near the face, head, neck or chest.

5. **Assess**: The oxygen delivery should be evaluated if it is still required after any local anaesthetic administration and stopped. If oxygen is still required, it should be reduced to the minimum required to prevent hypoxia.

6. **Confirm**: The operating room team should check that the oxygen supplementation has been minimised or stopped.

7. **Wait**: Allow time for oxygen concentration to be reduced (dissipate) before commencing the surgery.

Cognitive aid algorithm

A cognitive aid is provided in the form of a flow chart identifying the key steps and decision points to aid decision making regarding oxygen delivery.

Explicit recommendation:

If the patient requires ongoing oxygen supplementation in the setting of a high-fire risk ie 3 points (with or without sedation), consideration should be given to converting to a general anaesthetic and securing the patient's airway with a well-sealed supraglottic airway or endotracheal tube.

ANZCA
FPM

Fire Prevention Algorithm

START

Is the patient at risk for surgical fire?

Procedures involving the head, neck and upper chest (above T5) and use or an ignition source in proximity to an oxidizer

NO → **Proceed, but frequently reassess for changes in fire risk.**

YES

Nurses and surgeons avoid pooling of alcohol-based skin preparations and allow adequate drying time. Prior to initial use of electrocautery, communication occurs between surgeon and anaesthetist.

Does patient require oxygen supplementation?

NO → **Use room air sedation.**

YES

Is >30% oxygen concentration required to maintain oxygen saturation?

NO → **Use delivery device such as a blender or common gas outlet to maintain oxygen below 30%.**

YES

Secure airway with endotracheal tube of supraglottic device.

Although securing the airway is preferred, for cases where using an airway device is undesirable or not feasible, oxygen accumulation may be minimized by air insufflation over the face and open draping to provide wide exposure of the surgical site to the atmosphere.

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