Negative pressure rooms in operating theatres in the midst of an airborne pandemic

INTRODUCTION

Understanding the mechanism of transmission of the virus causing coronavirus disease (COVID)-19 is the key to designing preventative measures and breaking the chain of transmission. The mode of transmission is known to be from droplet spread (>5 microns), predominantly.[1] Airborne transmission is still debatable. The degree of transmission through airborne viral particles of aerosol size (<5 microns) is quite unclear. National and international guidelines recommend airborne precautions, when and where aerosol-generating procedures (AGP) are performed.[2,3] The distinction is important because it forms the divide between generic contact and droplet precautions, from resource-intensive engineering controls and personal protective equipment (PPE) requirements.[4]

NEGATIVE PRESSURE ROOM AND RESPIRATORY ISOLATION

The Australian and New Zealand Intensive Care Society (ANZICS) outlines a hierarchy of hazard controls in terms of the efficacy of exposure prevention, which is the fundamental method of protecting healthcare workers.[3] The hierarchy includes five strategies starting from PPE and moving through administrative control, engineering control, substitution, and elimination. Although PPE is the least effective and elimination is the most effective method of protection, substitution, engineering controls, and administrative controls provide an intermediate level of hazard control.

Neither elimination nor substitution would work with the current hazard in question. Engineering controls, by isolating people from the hazard at the source, scores the highest in the list of priorities to sustain staff protection. Administrative controls and PPE measures are adjuncts to the above central measure.

The aim of environmental control in an isolation room is to control the airflow, thereby reducing the number of airborne infectious particles that may infect others within the environment.[5] Engineering controls allow the control of the quality and quantity of supply and exhaust air, control of the pressure differentials across adjoining areas, and control of the dilution of infectious particles by increasing the air changes per hour and designing patterns of airflow for particular clinical purposes. It is imperative to keep regular standardised checks and maintenance as needed to ensure that the isolation room serves the purpose of construction.

Typically, patient care areas can be classified into four basic types based on the pressure differential across the room. It determines the kind of isolation precautions possible in each room.

Negative pressure isolation rooms (Class N) are used to care for patients who require airborne droplet nuclei isolation. The requirement of a negative pressure room is an air handling system that operates at a lower pressure with respect to adjacent areas, with air exhausted appropriately to prevent air recirculation.[5] The risk of utilising these rooms for patients other than those with infectious conditions is that when the negative air pressure is turned off, it may compromise the integrity of the mandatory mechanics required for infection prevention and control.

Positive pressure (Class P) rooms are used in operating theatres. The intent is to reduce the risk of airborne transmission of infection to a susceptible patient. The positive pressure air handling system within the room operates at a higher pressure (+30 Pa), with respect to adjacent rooms or spaces, and the air supply is filtered using high-efficiency particulate air (HEPA) filters.[6]

ANZICS recommends treating COVID-19 patients ideally in a class N room. If these are not available, Class S rooms (standard room air pressure) would be the next best option. The European Society of Intensive Care Medicine recommends that all AGP on COVID-19 patients are to be performed in negative pressure rooms. The Class A (alternating pressure isolation) rooms are no longer recommended due to the high risk of safety breaches. The Australian Health Facility Guidelines of 2016 state that patients with airborne transmitted infections should not be accommodated in Class P isolation. This is similar to the recommendations by health governance across Australia.[7]

As the requirement for respiratory isolation is considered ongoing and perennial, acute care areas
such as the intensive care unit and the emergency department are conventionally equipped with a minimum of one Class N room. However, operating theatres are conventionally equipped with positive pressure rooms. The benefits of reduced surgical infection to the patient, when operating in a positive pressure theatre complex, need to be balanced against the counter requirements of negative pressure rooms when considering staff safety against airborne pathogen exposure.\textsuperscript{[8]} AGP can result in higher airborne viral loads than under usual conditions. These AGP are routinely encountered peri-operatively.\textsuperscript{[9]} It is recommended to turn off the positive pressure system in the operating theatre, if possible, with concern lying primarily in the potential for contamination of any adjacent areas including intermediary anterooms, setup rooms and pre-anaesthetic areas.\textsuperscript{[10,11]}

Temporarily converting positive pressure rooms to negative pressure rooms, when the need arises, poses practical difficulties and has been explored too. Establishing standard compliance with effective negative pressure differentials in these units is challenging and comes with the added risk of utilisation of these rooms for non-COVID patients. A study performed in Hong Kong following the severe acute respiratory syndrome crisis studied the feasibility and efficiency of this process.\textsuperscript{[11]} The study reported the problems encountered, airflow design, and evaluated the performance of a converted room. Quality was assessed using regular air sampling checks and computational fluid dynamics. Results revealed that it was impossible to make the room enclosure totally airtight. The other significant problem was a back flow of contaminated air from the negative pressure theatre into the anteroom.\textsuperscript{[11]} The recommended adequate minimum air changes per hour (ACH) to prevent contamination of adjacent areas is >12 ACH.\textsuperscript{[12]}

In preparation for the future and while planning major hospital expansions, it would be worthwhile to consider incorporating negative pressure operating rooms as a part of the theatre complex, which is far easier and more cost-effective to establish and use, rather than temporarily transforming theatres into negative pressure units when the need arises. With increasing globalisation, the frequencies and volume of overseas travel are going to increase. Being prepared with adequate preventative strategies would go a long way in reducing the morbidity and mortality, health care burden and the cost incurred.

Actual requirements will depend on the assessment of data on health services, baseline infection rate and recent trends. Details of engineering requirements and services for isolation rooms are available from a number of sources.\textsuperscript{[7]}

**CONCLUSION**

Considering the changing dynamics in microbiology and in preparation for the future, it would be worthwhile to incorporate negative pressure rooms into the floor plans, for operating room expansions or construction. Although well-structured staff training programmes, suitable cognitive aids and appropriate PPE with strict hand hygiene are an integral part of infection prevention at the individual level, airborne precautions and respiratory isolation are imperative in managing COVID-19 patients or any other airborne infections safely in the future.

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