Air Dynamics Management (ADM) For Reducing Transmission of Covid-19 in Hospitals

The current pandemic of Covid-19 is mainly spread by inhaling droplets from infected people who are within two metres or less, and to some extent by aerosols of virus particles, which may persist in air for 30 minutes or more.

In May 2020 it was estimated that 20% of Covid-19 cases were acquired in hospital.

This paper looks at ways in which the hospital route of transmission may be significantly reduced.

The transmission risk from Covid-19 cases

People in hospitals who are known to be infected with Covid-19 are putting out droplets containing the Sars-CoV-2 constantly and in large amounts when they cough and speak, especially in the first week since symptoms began.

The exhaled air from patients on respirators and CPAP is not a problem, as their air is usually or always in a closed circuit, but milder Covid-19 cases who are receiving oxygen delivered via nasal cannula or mask will be continually exhaling droplets into the hospital environment. The air in their vicinity and in their room will contain a considerable quantity of virus, both as droplets and as aerosols.

Bed coverings and the floor within a couple of metres will be hosting significant amounts of virus. This virus will feed back onto the patient, continually re-infecting them every time they breathe in, or when they touch their face after letting their hands rest on their sheets. The floors can be cleansed at frequent intervals, but the bed linen presents an infection risk to anyone who handles it.

The air in the vicinity of the patient poses a health and safety risk to anyone who enters the room or indeed breathes air in the vicinity of the room. PPE is used to reduce this risk, but PPE does not present an impenetrable shield, and 649 healthcare workers (including 36 doctors) have died from Covid-19 contracted while giving care.

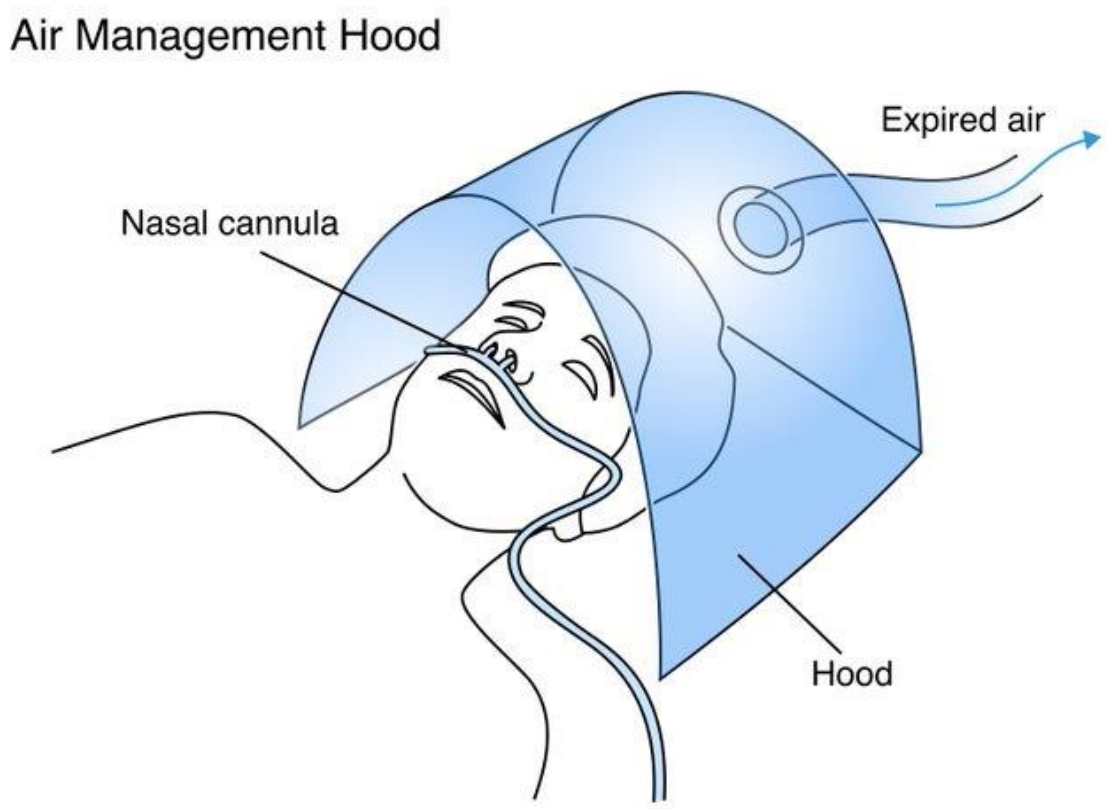
Systems to manage expired air

The above source of potential infection will be reduced significantly if all the exhaled breath from a Covid-19 sufferer is withdrawn and sterilised.

It may be the case that in some hospitals air from the general vicinity of the patient is already “scavenged” by an induction tube located at a distance from the patient, but this will not produce 100% capture of droplets.

The simplest way to capture expired air is by means of a hood positioned over the head. Air will be withdrawn from the hood through a tube positioned above the head at a rate in the region of 6 litres/minute that will prevent any expired air from escaping. The material of the hood will be of transparent plastic that can be sterilised. This hood will produce an upward flow of air across the face, and all expired air will be safely collected. See Fig 1 below.

Figure 1 – Air management Hood



Simple mask with exhaust tube

A mask may be used instead of a hood. It will be provided with and input and output tube. This means that much of the oxygen supplied will pass immediately into the exhaust air system, rather than passing into the air in the vicinity of the patient.

Mask with alternating flow

In another embodiment the mask may be designed so that oxygen is supplied when the patients are in the inspiratory stage of their respiratory cycle and cut off when the patients are in the expiratory stage of their respiratory cycle. Conversely the exhaust air duct will open with the expiratory phase of the respiratory cycle and close when they are in the inspiratory phase of the respiratory cycle.

This reciprocating flow may be produced by a simple valve design that will allow the patient to adjust the rate of the delivery cycle. The plan may be obtained from the author on request.

Assisted respiration

Alternatively, for patients with severely compromised respiration, electrically actuated valves could be provided which would be controlled by information from sensors sited on the patient's chest which would allow synchronised delivery and extraction of gases. The patient would receive useful

assistance in respiration from this arrangement. This is available as Positive End-Expiratory Pressure (PEEP).

Management of removed air

If the hospital or nursing home has only one or two patients with Covid-19, the air removed from the hood may simply be passed through a HEPA filter in the patient's room.

If there are several patients in the building, it may be better if each tube from the Covid-19 patient will be connected to a manifold, and the total air removed from all Covid-19 patients in a hospital (or nursing home) will be passed through a unit that will apply effective sterilisation by chemical means (e.g. sodium hypochlorite mist), physical means (e.g. ultraviolet light or heat) , or a combination of both, before venting to the atmosphere.

Many modern hospitals have a centralised (integrated) vacuum cleaning system that might be adapted to serve as a starting point for the air extraction ducts. The system will of course have to be modified to sterilise it of all pathogens.

Heat exchangers may be added to minimise heat loss from the establishment in colder months.

Using these simple technologies, hospital acquired Covid-19 infections, whether by other patients or by front-line staff, will be greatly reduced.

Discussion

Cost

There will be a small capital cost attached to fitting these air management tubes, fans, and sterilising facilities, but the costs will be recouped from decreased expenditure caused by hospital acquired infections affecting staff and even other patients.

It is possible that Government may be persuaded to subsidise these technologies in order to help to suppress the pandemic.

Apparatus will not have to be scrapped when the Covid-19 pandemic is over. Pandemics are arising more and more frequently as shown in this table:

Table 1

HIV/AIDS	~1940
Ebola	1976
Sars	2002
Mers	2012
Covid-19	2019

It can be seen that the interval between emergence of new infections is decreasing with time, and we can safely infer that new pandemics will occur from time to time, and therefore the demand for air quality management equipment will be sustained and increased.

Effect on the patient

Since patients are breathing and coughing out viral particles, they will be re-infecting themselves each time they breathe in and each time they touch their face. It is arguably the case that ADM will reduce the viral load that their immune system has to deal with, and therefore will aid recovery. It will be possible to test this hypothesis by reviewing patient outcomes a few weeks after the technology has been installed by auditing outcomes on patients treated with Covid Air Management.

Other measures

Air Management must be seen as one component of a systematic response. Hands, face and space must be continued alongside air dynamics management.

Noise

Attention must be given to the problem of noise associated with air management. Tubes will be of smooth bore rather than corrugated. Any valves will be made of soft material, and the points of impact of valves will be designed to avoid noise. Air flow will be laminar, and as slow as is possible compatible with amounts required for respiration.

Safety

There is a serious responsibility undertaken in managing air containing large amounts of Sars-CoV-2. System integrity is vital since leaks in delivery tubes could result new infections. Potential breakdown in the system of exhaust air management must be monitored with regular checks.

Conclusion

The advantages of the Covid emissions control system are:

1. Lessened risk of infection to front line staff - doctors, nurses, paramedics, and cleaners - entering the C19 patient's room
2. Lessened risk of infection in those breathing air drifting from the vicinity of C19 patients
3. Lessened stress and anxiety in front line staff
4. Possible faster recovery times for C19 patients as they will have less viral reinfection load from re-breathing their own air and touching and ingesting virus from their bed sheets
5. Less cost to hospital from staff losses due to self-isolation and staff illness
6. Less risk of litigation from individuals who contract Covid-19 in hospital

There is a strong case, both from a public health and a financial viewpoint, for hospital management to install Air Dynamics Management systems for Covid-19 patients.

Richard Lawson MB BS, MRCPsych rlawson@gn.apc.org 29/09/2020