IN BRIEF

- SARS is a highly infectious disease and dental personnel are likely to be at risk because of the nature of their profession, working in close proximity to the patient.
- Management protocol may be modified to minimise public health risks. This includes the identification, isolation, management and report of possible and probable cases and contacts.
- The principles of standard precautions should be followed.
- Effective infection control and treatment planning should include measures aimed at minimising the generation of, or contact with infectious droplets and aerosol.
- Modified universal infection control recommendations (now termed standard precautions) relevant to SARS is provided, based on different clinical scenarios.

Severe Acute Respiratory Syndrome (SARS) and the GDP. Part II: Implications for GDPs

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The transmission modes of SARS-coronavirus appear to be through droplet spread, close contact and fomites although air borne transmission has not been ruled out. This clearly places dental personnel at risks as they work in close proximity to their patients employing droplet and aerosol generating procedures. Although the principle of universal precautions is widely advocated and followed throughout the dental community, additional precautionary measures — termed standard precaution may be necessary to help control the spread of this highly contagious disease. Patient assessment should include questions on recent travel to SARS infected areas and, contacts of patients, fever and symptoms of respiratory infections. Special management protocols and modified measures that regulate droplet and aerosol contamination in a dental setting have to be introduced and may include the reduction or avoidance of droplet/aerosol generation, the disinfection of the treatment field, application of rubber dam, pre-procedural antiseptic mouthrinse and the dilution and efficient removal of contaminated ambient air. The gag, cough or vomiting reflexes that lead to the generation of aerosols should also be prevented.

INTRODUCTION

In the first part of this two-part article an account of the epidemiology, virology, pathology and management of Severe Acute Respiratory Syndrome (SARS) was provided together with public health issues and general aspects of infection control. In this concluding part we describe in detail the implications of SARS for the general dental practitioners together with infection control guidelines that may be applied in a primary dental care setting in the event of such an outbreak. The suggested guidelines have been modulated based on the promulgations by the British and North American infection control agencies, and our own close encounters with the SARS outbreak in Hong Kong.

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IMPLICATIONS OF SARS FOR THE GENERAL DENTAL PRACTITIONERS

SARS patients are unlikely to seek dental treatment in the early acute phase of the disease owing to the rapid course of the disease and the onset of fever as a primary symptom. Indeed, the observation that maximum infectivity coincides roughly with the presence of high fever, when the patients would be seeking medical rather than dental care,[1] appears to be the major reason for the absence of SARS infection in dental settings thus far.

Nonetheless, due to the highly infectious nature of the disease, and as the modes of transmission and infectivity are not fully understood, especially in the prodromal and convalescent stages of the disease dental healthcare workers maybe at risk of exposure to SARS-CoV. This is particularly the case as in dentistry the care provider has to operate in close proximity to the patient using droplet and aerosol generating procedures. The fact that the droplet spread mainly occurs within a 3 feet radius of the infective focus emphasizes this danger further.

THE SIGNIFICANCE OF DROPLETS AND AEROSOLS IN THE TRANSMISSION OF DISEASES

As discussed earlier, SARS is likely to be transmitted via droplets, close contact and fomites. When an individual coughs or sneezes, or when aerosol generating procedures are used particles of varying size (from 0.001 µm to up to 10,000 µm) are produced. Particles or droplets with a diameter greater than 100 µm, as most are, called splatter or spatter are then propelled through the air for short distances, generally 3 ft or less and settle rapidly on either animate or inanimate surfaces. Transmission of infection via droplets thus requires close contact with an index case.

On the other hand smaller droplets (or aerosols, generally under 10 µm in size) or small-particle residue of evaporated droplets are usually airborne and are entrained in the air for a lengthy period

and, may carry infectious microbes. They may be dispersed widely by air currents and the disease transmission thus become airborne.[2] It is salutary to note that the microbe-laden aerosol may also settle in surrounding areas in the clinic/office devoid of any clinical activities.

The infective dose of the organism is another important consideration that should be borne in mind when considering airborne infection. An influenza virus particle or a few spores of the *Aspergillus* fungus may have widely differing potentials for causing respiratory infection as is the viability of the microbes and the general health of the person inhaling them.

The foregoing risks to the dental professionals posed by airborne particles have been assessed and precautionary measures recommended elsewhere.[3,4]

The measures for controlling droplets and aerosols will be discussed later in this article.

RECOMMENDED MANAGEMENT PROTOCOLS

We describe in detail below the management protocols recommended for different clinical scenarios one may encounter in SARS-affected areas:

1. Possible and probable SARS cases.[5,6]
2. Patients diagnosed with SARS within 10 days of dental treatment.
3. Personnel who have had unprotected exposure to SARS patients.
4. Patients who have close contact with SARS patients within 10 days immediately prior to dental treatment.
5. Asymptomatic carriers including those who have had treatment for SARS.

The concept of 'standard precautions' should be applied regardless of the management protocols suggested below.

Patient evaluation

As is the routine, infection control measures begin with a thorough medical history questionnaire. The most recent case definition[5,6] for SARS should be used for screening purposes and special emphasis should be placed on the course of events 10 days prior to the dental appointment. The Health Protection Agency (HPA) of the UK has given guidelines[7] on patient assessment which includes a detailed travel history from patients with symptoms and a contact history with those who have had similar signs and symptoms of SARS. Specifically, the patient should also be asked, or temperature taken as the case may be, if he or she is running a fever (> 38 °C) or suffering from flu-like symptoms, myalgia, unproductive cough or diarrhoea. Once a SARS case is suspected, the dentist must immediately inform the health authorities.

1. Possible or probable SARS cases

In the unlikely event of a SARS patient, in the early phase of the disease, attending for a dental appointment priority should be given to minimising disease transmission. The patient should be immediately provided with a surgical mask and transferred to a secluded private area away from other patients or personnel.[7] The patient should be referred to hospital for assessment as directed by local health authority regulations, after rescheduling the dental appointment. Ideally, the health authority should arrange transport to hospital or a SARS clinic and all personnel involved must be informed and wear suitable protective garments.[7,8]

Dental management should be limited to the control of pain and infection in consultation with the patient's physician if indicated. No confirmed SARS cases with active infection should be treated in a general dental practice.

2. Patients diagnosed with SARS within 10 days of dental treatment

Laboratory data indicate that the SARS-CoV survives at room temperature for up to 2 days provided the conditions are optimum. For instance in cell-culture supernatants only one log reduction in viral load was noted at ambient temperature after 2 days.[9] Therefore, if informed by a physician or the local health authority that a patient recently treated at the dental surgery has been confirmed to have SARS, the following measures should be adopted:[1,7,8,10]

- Notify all persons (contacts) who were in the office within a 48-hour period from the time when the SARS patient was present. HPA advises that these contacts should stay indoors and keep contact with other people to a minimum for a period of 10 days from the time of last contact with the case.
- Advise all 'contacts' to inform their general practitioner (GP) immediately. They should keep in touch with the GP daily and seek medical advice as soon as symptoms develop or when recommended by the GP. The contacts should be monitored but need not to be in isolation unless symptoms appear.
- The dental office should be thoroughly disinfected using hospital grade germicide, and remain closed for at least 48 hours from the time when the SARS patient was present before re-opening

3. Dental personnel following unprotected exposure to SARS patient

HPA has recommended that exclusion from duty is not necessary for healthcare personnel after exposure if they remain asymptomatic or have followed normal infection control procedures[11] (the same rule applies to personnel who have travelled to a high-risk area). They should be monitored daily for fever and respiratory symptoms. Exclusion from duty is recommended if symptoms develop during the 10 days following unprotected exposure to SARS patients (or visit to high-risk areas), and for 10 days after the resolution of symptoms.[12] These personnel should always wear protective surgical masks irrespective of whether they are treating patients or not, during the 10-day observation period.

4. Dental patients who have come into close contact with SARS patients within the past 10 days

HPA considered 'close contacts' to be family, friends or healthcare workers who lived with, or who had direct contact with respiratory secretions, body fluids and/or excretions (eg faeces) of possible or probable cases of SARS (*see* below), while that case was symptomatic.[7] Examples of close contact include kissing or embracing; sharing utensils, close conversation, physical examination and physical contact.[5] They should be managed by pharmacological means over the 10-day isolation (incubation) period. Any acute symptoms that require immediate attention (eg temporisation or emergency endodontics) should be treated only if aerosol and splatter generation can be prevented or minimised by measures outlined below. Otherwise the patient should be rescheduled.

5. Asymptomatic carriers (including those who have undergone treatment for SARS)

In high-risk areas where there is a current or recent SARS outbreak, a person may have contracted the SARS infection leading to sub-clinical infection. Further, individuals who have recovered from SARS may carry the virus beyond the 10-day isolation period.[13] The infectivity of these patients is unknown.[14]

There is a dilemma regarding dental management of these symptomless individuals. On one hand, aerosol generating or potentially cough or vomit inducing dental procedures increases the risk of cross-infection whilst on the other, patients' well-being is compromised if treatment is not delivered. Some may consider this as unethical and ostracisation of those who have suffered SARS. Treatment planning and work practice should therefore be modified as stated above to minimise aerosol generating procedures and, according to some authorities, to take into considerations an approach to cohort convalescent cases for up to 3 weeks from the onset of illness.[15]

Corticosteroids are used in many centres for the treatment of SARS. As even a short-

term use may interfere with adrenal cortical responses[16] steroid cover may have to be considered as appropriate.

SPECIFIC INFECTION CONTROL MEASURES

A comprehensive review of dental procedures that incorporate universal and standard precautions is beyond the remit of this article as many recent reviews are available on this subject.[17,18] Rather we outline below special precautions that may be taken in dentistry to minimise droplet and aerosol production including the prevention of the gag, cough or vomiting reflexes leading to aerosols. All the measures outlined below need not be implemented at all times. Rather the practitioner should be cognisant of these and implement them appropriately as dictated by the clinical scenario.

Controlling the gag, cough and vomit reflex in patients

- Proper patient positioning and behaviour management is important. The patient should be relaxed and comfortable. Sedation may be considered and hypnosis has been reported to be useful for some patients.[19]
- Retraction and suction must be performed with care
- Intra-oral radiographs, especially bite wing and posterior films, may stimulate the gag reflex and one may consider using extra-oral views for screening purposes eg the OPG or the oblique lateral views instead of bite wings.[20]
- Trays may need to be adjusted for impression taking. Very sensitive patients may require anaesthesia of the oral mucosa before impression taking.[21] The use of topical spray for subduing the gag reflex is contraindicated to avoid the risk of an aerosol being generated. Lozenges may be used instead but its effect is not fully studied.[19] CAD-CAM technology, may be useful in some cases, to obviate conventional impression taking.[22]
- Patients suffering from traumatic injuries may have a significant amount of blood in the oral cavity. The reflexes may be induced if blood is swallowed or aspirated so effective evacuation is important.

Measures for controlling droplets and aerosols

To minimise the likelihood of airborne disease transmission via droplets or aerosols, the dental team adopts the following:

1. Reduction or avoidance of droplet/aerosol generation
2. Use of rubber dam isolation
3. Use of pre-procedure mouthwash
4. Dilution and efficient removal of contaminated ambient air
5. Disinfect air/aerosol generated
6. Adoption of contact precautions

1. Reduction or avoidance of aerosol/droplet generation[3]

- Aerosol and splatter generation is inevitable when ultrasonic scalers,[23] rotary brushes and air prophylactics are used. If conditions dictate, manual scaling and brushing should be used as similar clinical results could be obtained[24] without aerosol generation.
- Avoid the use of rotary handpieces for operative procedures if possible.[25] In selected cases, procedures such as chemo-chemical caries removal[26] or the atraumatic restorative technique (ART)[27,28] maybe useful.
- Minimise the use of a 3-in-1 syringe as this may create droplets due to forcible ejection of water/air. Disinfectants (hypochlorite, ethanol) in the handpiece and 3-in-1 syringe water supplies have been reported to reduce viral contaminants in splatter, but its action on human coronavirus is unknown.[29]
- Some surgical procedures, eg bone guttering, may have to be delayed or referred as effective evacuation cannot be achieved via surgical suction tips. If surgery is absolutely necessary for the management of periodontal disease, open debridement may be considered as no aerosol is generated and the clinical outcome is favourable.[30]
- Defer elective, aerosol generating dental treatments 20 days (two infection cycles) after the community outbreak of SARS has subsided
- *A note on the use of lasers*. It is known that when lasers and electrosurgery are used, the smoke (plume) generated may contain microbes.[31,32] Laser plume has been shown by Garden *et al*. to actually transmit the papillomaviral DNA.[33] Although these results cannot be directly translated to include SARS-CoV, care should be exercised when these units are used.

2. Use of rubber dam isolation

Rubber dam effectively isolates the operating field and its use is well known to prevent or minimise the generation of potentially infectious splatter and aerosol.[34,35] For the majority of restorative procedures, eg operative and endodontic treatments, the application of rubber dam and the use of high volume evacuation will significantly reduce the risk of droplet transmission and help control the reflexes.

- For crown and bridgework, treatment planning may be altered to incorporate rubber dam application. For example, crown margins may be placed supragingivally or a split-dam procedure used.
- Rubber dam can be applied during tooth preparation for dentures.
- Adjuncts such as light-cured block out resin (eg opal dam Ultradent) can be used where effective isolation by rubber dam cannot be achieved (eg repairing a conventional bridge).

3. The use of pre-procedural mouthwash

A pre-procedural 0.12% chlorhexidine mouth rinse can reduce the microbial load of saliva, and by implication a resultant aerosol due to instrumentation.[36] Although the effect of chlorhexidine gluconate on human coronavirus is unknown it is effective against many respiratory viruses, like herpes and HIV.[37]

4. Dilution and removal of contaminated ambient air

This could be performed through using one or more of the following measures, namely: high volume evacuation (HVE), improving the general ventilation and effectively controlling the airflow patterns and filtration of the circulating air. In clinics where air-conditioning is not available all windows should be kept open to encourage natural ventilation as much as possible.

High volume evacuation (HVE). HVE prevents or minimises the dispersion of infectious droplet nuclei into the air by removing them at the source as they are emitted. It is important that the filters in the suction apparatus are cleaned daily in order to maintain its efficacy and the exhaust air vented outside to prevent recirculation.

Extra-oral evacuation devices and special aerosol reduction devices (ARD) designed for use in conjunction with ultrasonic scalers are now available and are considered useful in further reducing the amount of droplets and aerosols.[36,38]

General ventilation. The air quality may be improved by controlling the airflow patterns. The ventilation systems should be designed such that fresh incoming air mixes with and dilutes the contaminated ambient air and the mixture is then removed by an exhaust system. Air stagnation or short-circuiting of air directly from the supply to the exhaust is thus prevented. An optimal pattern of airflow (eg air movement from the ceiling towards the floor area) with a minimum of three air changes per hour (ACH) is generally recommended for dental surgery settings.[39–41]

Air filtration. Air filtration could be effectively performed by using high efficiency particulate air (HEPA) filters that achieve a particle removal efficiency

(PRE) of 99.97% at 0.3 µm. Although aerosols may have a smaller diameter, testing has shown that smaller particles do not penetrate as readily as 0.3 µm particles.[42]

HEPA filters may therefore be used in exhaust ducts or any fixed or portable room-air cleaners.[43] Its use in dentistry may still be controversial as:

- It is difficult to efficiently direct the flow of aerosol towards the filter.
- The amount of aerosol filtered is limited per unit time and dental procedures generate a large amount of aerosols in a relatively short period of time thus overloading the device.
- Filters have to be leak-proof to be effective.
- The air inlet and exhaust are adjacently situated in small units (eg those suggested for use in relatively small spaces as in dental clinics) thus causing 'short-circuits' and reducing the filtration efficacy.[41]

5. Disinfection of air/aerosol

A number of new air disinfection systems are commercially available. However, the technologies used are varied and their efficacy in dental clinic settings or indeed against the SARS-CoV are as yet unproven. These are outlined below:

Ultraviolet germicidal irradiation (UVGI). Ultraviolet radiation is produced by using mercury vapour arc lamps at a wavelength of 253.7 nm, within the UV-C bandwidth of the electromagnetic spectrum. It damages the DNA of microbes rendering them non-infectious and is effective against a wide range of airborne pathogens.[41] The efficacy of UVGI depends on:

- Energy generated ie the intensity of UVGI.[44]
- Air movement ie amount of aerosol passing the device per unit time.[44]
- Whether microorganisms are protected by moisture or particulates, and
- The duration of the exposure.

At present these devices are primarily used as wall-mounted fixtures in some health institutions. They are thought to offer effective filtration against fungi, viruses and bacteria including tubercle bacilli and anthrax spores.[41] Their installation, use and maintenance have to be closely monitored to prevent occupational hazards.[45] The use of UVGI in dental surgeries is unproven.

Photocatalytic oxidation (PCO). Photocatalytic oxidation (PCO) is based on the principle that irradiated titanium dioxide (TiO_2) produces reactive oxidising radicals that disinfect adsorbed aerosols by oxidising their volatile organic content.[46] This technology has been incorporated in room air decontamination devices although their performance is significantly affected by the water content of the air stream. Other factors that may affect its efficiency include temperature, initial contaminant concentration, flow rate and the light intensity.[47]

Ozone air purification. The high oxidation potential of ozone is used in a number of air purification products although it is not used in dentistry for this purpose. The action of ozone against microorganisms and its use in treating root caries lesions has been described.[48] However, the level of ozone has to be monitored as excessive levels may cause inflammation and impaired lung function and patients with respiratory problems such as asthma may be particularly sensitive.[49,50] Molfino *et al.*[51] showed that even low ozone concentrations could increase the bronchial responsiveness to allergens in atopic asthmatic subjects.

6. Contact precautions

Aerosols containing the SARS-CoV may be deposited on dental surgery surfaces especially in close proximity to the surgical areas. Further, the SARS-CoV has been shown to survive for up to 2 days on fomites (much longer than the influenza virus or HIV) and, contact with SARS-CoV particles-laden organic or inorganic debris is considered a significant mode of transmission of SARS-CoV.[13,52–54]

The established practices of universal/standard precautions already include protocols that effectively deal with this issue. The following points are highlighted for the prevention of SARS-CoV infections:

- Thorough hand washing should be done frequently and after treatment, contact with patient or fomites and before or after handling protective gear. It is a critical measure in controlling the spread of infection[55] and its benefits proven in preventing the spread of methicillin-resistant *Staphylococcus aureus* (MRSA) and various other infections in hospital settings.
- The use of disposable barriers on surfaces likely to be contaminated.
- All instruments and material should be dispensed before treatment to avoid cross contamination.
- Disinfect surfaces after each patient visit (hospital grade disinfectant including quaternary ammonium-based, phenol-based, and alcohol-based products are effective against coronavirus.)[56]
- Disinfections of impressions and prostheses, to and from the laboratory.
- Sterilisation of soiled instruments. The effectiveness of the sterilisation process should be monitored and results recorded in a logbook.
- The use of single-use disposable items is encouraged.
- All clean instruments must be stored in covered containers or storage units to prevent particles from settling on the surfaces of the instruments or packages.
- Personal protective equipments (PPE) should be worn. These include gowns/over-garment, hair covers, masks, gloves, goggles, face shield and shoe covers. The donning and removal of PPE should be done in designated areas.[40]

A note on personal protection equipment (PPE)

- Masks have been shown to be useful against nosocomial transmissions of SARS.[54] As the most penetrating particulate size is 0.3 µm, a mask with a specification of PFE (particle filtration efficiency) 99% (or above) at 0.1 µm may be more useful although it is uncomfortable to wear for a prolonged period.
- HPA recommends the use of USA standard N-95 respirator or the European standard EN149:2001 FFP2 for routine airborne isolation precautions. Use of higher levels of respiratory protection may be considered for certain aerosol-generating procedures when treating confirmed or highly suspected SARS cases.
- Masks or respirators must be changed according to the manufacturer's recommendations. Furthermore, the filtering efficiency of a mask is only as good as its fit or the moisture content. Therefore masks and respirators should be fit checked and always discarded if moist/ wet.
- Eye protection and face shields are also recommended when there is a potential for splattering or spraying respiratory secretions.[40]
- Long cover gowns should be worn and sleeves secured under the gloves to prevent exposure of any part of the forearm. Re-usable garments should be changed when visibly soiled or penetrated by fluids and placed in marked containers after use. Contaminated garment should be laundered using a normal laundry cycle.[57]

CONCLUSIONS

It is the duty of all dental professionals to maintain a safe practice environment free from infectious hazards. The principles of universal precautions is widely advocated and followed throughout the dental community. However it is believed that in the wake of the SARS crisis, practitioners should pay heed to additional precautionary measures now termed *standard precautions* discussed in this paper in order to help control the spread of this highly contagious disease, as well as other respi-

ratory diseases such as tuberculosis. It is likely that a vaccine would be available against SARS in the not too distant future, but until then prevention is the only weapon available against this disease.

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