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Aerosol-generating procedures in head and neck surgery – can we improve practice after COVID-19?

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Abstract

The COVID-19 pandemic has had a dramatic impact on international medicine practice. The propensity for head and neck surgery to generate aerosols needs special consideration over and above simply adopting personal protective equipment. This study sought to interrogate the literature and evaluate whether which additional measures might provide benefit if routinely adopted in minimising viral transmission.

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Keywords: COVID-19; aerosol-generating procedures; high-volume suction; pre-procedural mouthwash

Introduction

A novel coronavirus was first encountered in Wuhan, Hubei Province, China, in December 2019 when patients started to present with community acquired pneumonia.¹ As a result of global travel the virus was rapidly disseminated to all provinces of China and 25 countries in Asia-Pacific region, North America, Europe, and South America within one month of its discovery.² On 11 February 2020 the World Health Organization (WHO) renamed the disease as the Coronavirus Disease 2019 (COVID-19) while the virus was classified as SARS-CoV-2 by the International Committee on Taxonomy of Viruses. The four United Kingdom (UK) Chief Medical Officers raised the country's risk level from low to moderate on 30 January 2020 upon the WHO's announcement of the disease as a Public Health Emergency of International Concern (PHEIC).³ The UK's emergency

response to the COVID-19 pandemic thereafter stems from protocols that were developed both during and after the Severe Acute Respiratory Syndrome (SARS) epidemic of 2003. However major differences exist between SARS and COVID-19 in that the former was considerably more dangerous with a cumulative fatality rate (CFR) of 11% compared to an estimated CFR for COVID-19 of <1%.^{4,5}

Aerosol-generating procedures (AGPs) are prevalent in head and neck surgery and it is likely that practice will have to change as a result of the COVID-19 pandemic at least in the short term. On 27 March 2020 Public Health England published updated guidance on personal protective equipment (PPE) suggesting the need to limit the use of fluid resistant surgical facemasks (FRSM) to non-AGP procedures and FFP2/FFP3 for AGPs.⁶ Given that sources of PPE are variable and may remain so in the future we sought to review the literature to investigate whether any additional lessons could be transposed from either the SARS or early COVID-19 experience into head and neck surgery to aid healthcare workers in both the out-patient and operating theatre environments.

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Material and methods

We carried out a literature review over the past two decades amongst Ovid (Medline) and Scopus (Elsevier) along with the Cochrane databases with an English language restriction. The topics thought most worthy of consideration related to high-volume suction/aspiration and pre-procedural mouth washing. Given that many of these topics are also pertinent to the practice of dentistry search terms included 'dentistry', 'dental' and 'dental care'. Abstracts were evaluated and full-text articles obtained as relevant.

Results

A small number of studies fulfilled the search criteria in relation to high-volume suction/aspiration. Jacks designed a study to compare the concentration of airborne particulates using different methods of evacuation generated airborne particulates from a 25,000 cps magnetostrictive ultrasonic scaler instrument in a laboratory setting.⁷ A standard saliva ejector positioned intraorally was compared with two extraorally positioned, hands-free high-volume evacuation (HFHVE) techniques (standard attachment and funnel-shaped attachment). Measurement of airborne particles was performed with a DataRAM Real-Time Aerosol Monitor. A significant reduction in the number of airborne particulates was demonstrated with both forms of extraoral HFHVE attachment in place. Standard attachments and funnel-shaped attachments resulted in reduction of particulates by 90.8% and 89.7%, respectively, when compared to the intraorally positioned standard saliva ejector. A second in-vitro study used an ultrasonic scaler to generate an erythrosin dye solution aerosol at 17.5 ml/min with a high-volume evacuator being used to assess the reduction in contamination within a plastic enclosure containing a 1 cm grid laid out on 4 slides.⁸ The number of squares containing a red erythrosin spot were counted and considered to represent aerosol contamination. The high-volume evacuator attachment produced a 93% reduction in the number of contaminated squares (chi squared significant at $p < 0.05$). In the only in-vivo study 30 subjects had half their mouths cleaned using an ultrasonic scaler as a control and the other half using high-volume suction.⁹ Four culture plates were placed on the operator and patient with high-volume suction resulting in an 81% reduction in mean bacterial culture forming units (CFUs).

The use of pre-procedural mouthwashes in reducing bacterial contamination is well established.^{10–12} There is some evidence that similar mouthwashes might demonstrate virucidal properties with Eggers et al investigating the efficacy of povidone-iodine (PVP-I) 7% gargle/mouthwash at defined dilution against oral and respiratory tract pathogens. PVP-I was tested against *Klebsiella pneumoniae* and *Streptococcus pneumoniae* according to a bacterial quantitative suspension test and against severe acute respiratory syndrome and Middle East respiratory syndrome coronaviruses (SARS-CoV

and MERS-CoV), rotavirus strain Wa and influenza virus A subtype H1N1 according to virucidal quantitative suspension test EN14476.¹³ The PVP-I 7% gargle/mouthwash was diluted 1:30 with water to a concentration of 0.23% (the recommended concentration for real-life use) and tested at room temperature under clean conditions [0.3 g/l bovine serum albumin (BSA), viruses only] and dirty conditions (3.0 g/l BSA +3.0 ml/l erythrocytes) as an interfering substance for defined contact times (minimum 15 s). Rotavirus was tested without protein load. A $\geq 5 \log_{10}$ (99.999%) decrease of bacteria and $\geq 4 \log_{10}$ (99.99%) reduction in viral titre was used to represent effective bactericidal and virucidal activity respectively. The diluted PVP-I gargle/mouthwash showed effective bactericidal activity against *Klebsiella pneumoniae* and *Streptococcus pneumoniae* and rapidly inactivated SARS-CoV, MERS-CoV, influenza virus A (H1N1) and rotavirus after 15 s of exposure. Kariwa likewise reported that the treatment of SARS-CoV with PVP-I products for two minutes reduced virus infectivity from 1.17×10^6 TCID₅₀/ml to below the detectable levels.¹⁴ The use of similar regimens has been suggested might be of benefit in reducing healthcare worker exposure during the COVID-19 pandemic.¹⁵

Discussion

Aerosols are defined as airborne particles that range in size from 0.5 to 10 microns. They are universally produced during instrumentation of the upper aerodigestive tract but can be reduced. Irrigant solutions, which produce the therapeutic effects of lavage, also combine with blood, saliva, and bacteria to produce potentially harmful airborne particulates.

Saliva contains a high viral load in COVID-19 with up to 1.2×10^8 infective copies/mL.¹⁶ PCR assay techniques have demonstrated that the nasopharynx appears to have a higher viral load than the oropharynx suggesting that reduction of nasal viral titres may be of at least as much importance as the oral cavity/oropharynx.¹⁷ Viral load in sputum from the lower respiratory tract is also of importance with the suggestion that viral shedding is high during the early phase of illness and more prominent in the upper compared with the lower respiratory tract.^{18,19}

High-volume suction draws a large volume of air away from the oral and nasal environment during operative procedures and in so doing reduces the amount of aerosol. Whilst intraoral suction devices such as those employed in dental surgeries are not universally present within the hospital environment, most out-patients and all operating theatres have access to some sort of high-volume suction equipment. Suction units in dental surgeries operate with a compression unit of 50 litres/min at 5 bar and require a minimum of 250 litres of air per minute. Operating theatre suction typically produces flow rates of 50 litres / min at 675 mmHg (0.89 bar) with the wall-mounted units housed in many out-patient consultation suites producing a flow rate of 30 litres/ minute at

650 mmHg (0.86 bar). Whilst the evidence base for effective aerosol reduction revolves around the dental literature transposition into the hospital setting seems justified even though there is a disparity regarding the flow efficiency of the units involved. Unlike the out-patient environment operating theatres most commonly utilise a conventional plenum-type ventilation system that operates under positive pressure. This allows 25 air changes of a non-recycled air flow supply with outflow to the atmosphere via overhead exhaust vents located in the adjoining scrub and anaesthetic induction rooms. Nevertheless it would appear that routine the use of high-volume suction equipment would be an effective policy to evacuate generated airborne particulates and so reduce the number that reach the breathing space of clinicians. Such measures could easily be adopted in the clinic and operative settings for a variety of procedures (e.g. out-patient nasendoscopy, panendoscopy under general anaesthesia).

Minimising, or at least reducing, viral titres in saliva and nasal mucous expectorated by COVID-19 patients should another avenue employed in the battle to reduce transmission of the disease. Doing so may well lessen the overall impact on the healthcare system by reducing cross-infection from patients to healthcare workers and vice versa. Whilst direct testing and demonstration of the virucidal activity of PVP against SARS-CoV-2 has not been documented the evidence in the literature shows that PVP-I is rapidly virucidal in vitro and reduces the coronavirus load in the oral cavity to help prevent MERS-CoV transmission.¹³ Topical PVP-I usage is well tolerated, inexpensive and, for a patient about to undergo a procedure, a one-off episode. However, healthcare workers may choose to adopt PVP-I use over a more regular and sustained period. Daily use of 5% PVP-I mouthwash over a six-month period does not appear to influence thyroid hormone levels (serum T3/T4 and free T4) and although a small increase in TSH levels may result the latter remains within the normal range.²⁰ In a study looking at the excretion of iodine in healthy subjects, average ingestion of 88 mg per day for a period of 38 days was undertaken without deleterious effects with the majority of iodine being cleared by the kidneys.²¹ The WHO recommended daily allowance of iodine for an adult is 0.15 mg. PVP-I 10% contains an equivalent of 11 mg/mL of iodine suggesting that with daily use 4 mg of iodine would be delivered per day to staff depending on the method of application. Since aerosolised secretions from the lower respiratory tract almost certainly also have a part to play in disease transmission such an approach clearly only forms one part of a strategy to reduce transmission as an adjunct to other elements of personal protective equipment. The suggestion that tempering Chlorhexidine rinses (47 °C vs 18 °C) may reduce bacterial aerosol contamination further is untried with viral load.¹²

A recent systematic review and rapid review of surgical masks versus FFP3 masks found no statistical difference in effectiveness between the masks regarding influenza like viral infections.^{22,23} The filtration capacity of a standard surgical face mask is highly variable compared to an FFP2 or

FFP3 mask. Oberg et al concluded that none of the surgical masks tested in-vivo on 40 subjects exhibited adequate filter performance and facial fit characteristics to be considered respiratory protection devices.²⁴ The mean penetration by 0.8 µm latex spheres was 37.89 (95% CI: 25.8% to 50.0%).

In the dental surgery high-volume aspiration can be supplemented by a physical barrier (e.g. rubber dam) and in such an environment there may be no significant additional benefit in wearing an FFP3/FFP2 over a surgical mask. There is a much larger difference if the quality of the HFHVE is reduced or where, in procedures such as head and neck surgery, a physical barrier is impractical. High-volume suction reduces bioaerosols by between 81% to 90%. Manufacturers suggest that fluid resistant surgical facemasks filter 62% of airborne particles compared with 94% for FFP2 masks and 99% for FFP3 masks. Given the lower suction efficiency of hospital-based suction equipment compared to that available in dental practices it is possible to estimate an overall reduction in AGPs with routine hospital suction use of 92.8% for the surgical mask, 98.9% for FFP2 masks and 99.8% for FFP3 masks respectively with a risk difference of 7.03 between the surgical mask and FFP3 and a relative risk of 0.929.

These results are hypothetical and due to the lack of specific studies of virus penetration of facemasks are based on surrogate and composite outcomes. There is an urgent need for more specific studies to address these issues in the clinical environment.

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The authors have no financial, personal, political, or academic interests to declare in relation to the content of this study.

Conflict of interest

We have no conflicts of interest.

Ethics statement/confirmation of patients' permission

Not applicable.

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