converting enzyme 2 (ACE2) receptor, which allows entry into the host cell.[2], [3], [4] COVID-19 infection creates a cytokine storm, severe pneumonia, multiple-organ failure, and acute cardiac injury.[5,6]

Transmission occurs through touch or aerosol spreading of the virus. A common pathway of spreading this virus is through respiratory aerosols from an infected person.[7] During speech, humans emit thousands of oral fluid droplets per second that can remain airborne for 8 to 14 minutes.[8] COVID-19 is detectable for up to 3 hours in surface aerosols, for up to 4 hours on copper, for up to 24 hours on cardboard, and for up to 2 to 3 days on plastic and stainless steel.[9,10] There is a need to disinfect surfaces potentially exposed to COVID-19 to prevent transmission.

Use of Disinfectants

On contact with the virus, a disinfectant agent changes the protective protein coat, which loses its structure and aggregates, forming clumps of proteins with other viruses.[9,10] Currently, the US Environmental Protection Agency has recommended numerous disinfectants against COVID-19 including hypochlorous acid (HOCl).[11] The mechanism of disinfection involves the destroying of the cell wall of microbes or viruses, allowing the disinfectant to destroy or inactivate them.[12], [13], [14], [15], [16], [17], [18], [19], [20], [21], [22], [23], [24], [25], [26], [27] This article focuses on HOCl.

Hypochlorous Acid

An ideal disinfectant and sanitizer must be nontoxic to surface contact, noncorrosive, effective in various forms, and relatively inexpensive. HOCl may be the disinfectant of choice for coronaviruses in an oral-maxillofacial surgery (OMS) office.

HOCl is an endogenous substance in all mammals and is effective against a broad range of microorganisms. Neutrophils, eosinophils, mononuclear phagocytes, and B lymphocytes produce HOCl in response to injury and infection through the mitochondrial membrane–bound enzyme known as “respiratory burst nicotinamide adenine dinucleotide phosphate oxidase.”[28] HOCl selectively binds with the unsaturated lipid layer and subsequently disrupts cellular integrity. Between pH levels of 3 and 6, the predominant species is HOCl that has maximal antimicrobial properties.[29,30]

HOCl is a powerful oxidizing agent. In aqueous solution, it dissociates into H^+ and OCl^-, denaturing and aggregating proteins.[30] HOCl also destroys viruses by chlorination by forming chloramines and nitrogen-centered radicals, resulting in single- as well as double-stranded DNA breaks, rendering the nucleic acid useless and the virus harmless.[31]

Wound Care

In a clinical study on intraperitoneal wound care, patients underwent lavage of the peritoneal cavity with 100-ppm HOCl and washing of the wound with 200 ppm.[49] No adverse effects were observed.

HOCl has been shown to be an effective agent in reducing wound bacterial counts in open wounds.[50] In irrigation solution in an ultrasonic system, HOCl lowered the bacterial counts by 4 to 6 logs. By the time of definitive closure, the bacterial counts were back up to 10^5 for the saline solution–irrigated control wounds but remained at 10^2 or lower for the HOCl-irrigated wounds. Postoperative closure failure occurred in more than 80% of patients in the saline solution group versus 25% of those in the HOCl group.

Hand Sanitizing

Hand antiseptics are alcohol based or non–alcohol based containing antibiotic compounds.[51] Chlorine-based sanitizers, at a concentration of 50 to 100 ppm, are effective against bacteria and viruses.[52] HOCl specifically used for hand sanitizers is effective at 100- to 200-ppm strengths.[53,54]

Surface Application

A study looked at disinfecting outpatient surgical centers using HOCl.[55] After cleaning, the rooms in the HOCl cleaning and disinfection study arm had significantly lower bacterial counts than the rooms that underwent standard cleaning and disinfection.

HOCl Applied by Spray or Fogger

A fogger takes a solution and creates a small aerosol mist, ideally less than 20 μm in size, to disinfect an area. HOCl fogs are highly effective in the microbial disinfection of surfaces. The fogging process can alter the physical and chemical properties of the disinfectant. It was found that fogging reduced the AFC concentration by approximately 70% and increased the pH by approximately 1.3, making the solution slightly more basic; it is speculated that the loss of chlorine resulted from evaporation of chlorine gas.[56,57] Because the changes in the properties of hypochlorous fogs are predictable, pre-fogging adjustment of the concentration and pH of the solution makes it possible to control the concentration levels to the desirable range to inactivate pathogens after fogging.[40] When the appropriate concentrations are used, a study found 3 to 5 $\log_{10}$ reductions in both the infectivity and RNA titers of all tested viruses on both vertical and horizontal surfaces, suggesting that fogging is an effective approach to reduce viruses on surfaces.[40,58]

HOCl solutions appear to be virucidal based on concentrations above 50 ppm. HOCl was evaluated against a low-pathogenic avian influenza virus (AIV), H7N1.[59] The HOCl solutions contained 50-, 100-, and 200-ppm chlorine at pH 6. Spraying with HOCl

decreased the AIV titer to an undetectable level (<2.5 $\log_{10}TCID_{50}$/mL) within 5 seconds, with the exception of the 50-ppm solution harvested after spraying at a distance of 30 cm. When HOCl solutions were sprayed directly onto sheets containing the virus for 10 seconds, the solutions of 100 and 200 ppm inactivated AIV immediately. The 50-ppm solution required at least 3 minutes of contact time. These data suggest that HOCl can be used in spray form to inactivate AIV.[59,60] When the aerosol was not sprayed directly onto an inoculated surface, a lower amount of solution had a chance to come into contact with the AIV. It required at least 10 minutes of contact to be effective.[61]
The ability of a sprayer to make smaller particles may help a solution's molecules to be suspended in the air for a longer period because of their low settling velocity rate. This may increase the solution's chance of coming into contact with pathogens and inactivating them. Thus, the fogger used should have an aerosol size less than 20 μm.[62]

Discussion

The coronavirus pandemic has caused both a massive health care and economic disruption across the world. The current unavailability of an effective antiviral drug or approved vaccine means that the implementation of effective preventive measures is necessary to counteract COVID-19. Oral-maxillofacial surgeons are high-risk providers providing needed care to patients. As more OMS and surgical offices open during reopening in the United States and elsewhere in the world, the need to reduce the risk of transmission of COVID-19 between patients and providers is necessary. It is widely believed that with proper screening and discretion, along with adequate personal protective equipment, there is a low probability of becoming infected. The goal of this article is to provide information regarding disinfection in the clinical office setting using HOCl, a relatively inexpensive, nontoxic, noncorrosive, and well-studied compound.

HOCl has uses in many industries from farming and restaurants, regarding food, to health care applications, including chronic wound care and disinfection.[34,36,43,45,46,63] In addition to the use of HOCl as a liquid-based disinfectant, fogging with hypochlorous vapor has shown virucidal activity against numerous types of viruses and bacteria.[40,56,57] This is of potential benefit to disinfect large spaces such as medical and dental offices where aerosols can be airborne for extended periods.[42,44,64] In terms of particle size, oral-maxillofacial surgeons may be at a slightly lower risk than their dental counterparts because ultrasonic scaling and high-speed handpieces create smaller particles that remain airborne longer.[42] However, aerosols are still created with surgical handpieces. Additionally, the COVID-19 virus can be present on some surfaces for

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