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Review Article

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The COVID-19 Pandemic and Face Shields: A Review

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Abstract

Introduction: The coronavirus disease 2019 (COVID-19) pandemic has placed personal protective equipment (PPE) for health care workers (HCW) in the spotlight. HCW's face has been reported to be the body part most commonly contaminated by body fluids. The aim of this narrative review to examine the current evidence on face shield as a PPE for droplet or aerosol prevention.

Methods: A literature search was conducted on the PubMed, MedLine, and Embase databases, with the keywords "face shield", "visor", and "droplet precaution". Biblio graphic search was also under taken.

Results: Respiratory droplet is particle with diameter greater than 5 µm, while aerosol are ≤ 5 µm according to the World Health Organisation. However, infection is not neatly separated into the dichotomy of droplet versus air borne transmission route. Modelling and simulation have shown the importance of the conjunctival mucosa as a route of transmission of disease in blood splashes, droplets and aerosols containing virus. The limited reports from SARS, COVID-19 and influenza season supports its use. However, HCW do not routinely use face shield if they consider the procedures to be unlikely to be associated with potential contamination. They also erroneously believe that prescription glasses is adequate protection. The issues associated with eye shield use, may be less of a problem with face shield.

Conclusion: Transmission of viruses is multimodal, and the conjunctival mucosa presents a real risk for viral transmission. Eye and face protection is important to prevent transmission of COVID-19.

Keywords

Retinal pigment epithelium, Photoreceptor cells, Optical coherence tomography, Fluorescein angiography, Macular degeneration (MeSH terms)

Abbreviations

COVID-19: Coronavirus Disease 2019; PPE: Personal Protective Equipment; HCW: Healthcare Workers; PETG: Polyethylene Terephthalate Glycol; OSHA: Occupational Safety and Health Administration

Introduction

The coronavirus disease 2019 (COVID-19) pandemic has placed personal protective equipment (PPE) for health care workers (HCW) in the spotlight. Certain professions, like dentists and otorhinolaryngologistshave a higher overall cumulative risk of exposure to splash, droplets and aerosols during their clinical practice. The global shortage of PPE for HCW, has resulted in vulnerability to the transmission of CVOID-19 and mortality. HCW's face has been reported to be the body part most commonly contaminated by body fluids [1]. There are other occupational hazards apart from COVID-19. The cumulative lifetime risk of a surgeon becoming infected with hepatitis C is 6.9% and HIV is 0.15% [2]. The estimated HIV transmission risk with mucocutaneous contact is 0.1% [2].

Transmission is influenced by various factors like: Pathogens, ventilation, air filtration, sterilization and PPE [3]. A face shield is a PPE that provides barrier protection to the facial area and related mucus membranes of the eyes, nose and lips, from spray or splash blood, body fluids, secretions or excretions [1,4]. It has received less attention compared to surgical masks and respirators. This is likely because it is easily manufactured, and industry like 3 dimensional printing, or additive manufacturing has stepped in. The aim of this narra-

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tive review to examine the current evidence on face shield as a PPE for droplet or aerosol prevention.

Matherial and Methods

A literature search was conducted on the PubMed, MedLine, and Embase databases, with the keywords "face shield", "visor", and "droplet precaution". Bibliographic search was also undertaken. The abstracts were scanned to assess their appropriateness to be included in this narrative review.

Discussion

PPE recommended for droplet precautions include gloves, gown, surgical mask and eye protection and or face shield, depending on the anticipated exposure to patient secretions. Face shield captures body fluid splatters, and alters the particle size distribution and magnitude of inhaled aerosols [5]. It covers a larger area than a face mask with visor or goggles, and limit splash and sprays on to face, surgical masks and respirators, which may increase the risk of self contamination during doffing [5]. Occupational Safety and Health Administration (OSHA) mandates that masks in combination with eye protection devices such as glasses with solid side shields, goggles, or chin length face shields when splashes, spray, splatter or droplets of blood or other potentially infectious material may be generated, and eye, nose or mouth contamination can be reasonably anticipated [6].

There are several parts to it: Visor, frame, and suspension system [1]. Shields are manufactured from polycarbonate, proprionate, acetate, polyvinyl chloride and polyethylene terephthalate glycol (PETG) [7]. It can be disposable, reusable, and replaceable [1]. Acetate provides the best clarity and is scratch resistant [1]. PETG is the most economical [7]. Polycarbonate is most widely used as it offers better optical quality that reduces eye strain associated with face shield wear [1]. Proprionate also has the similar optical quality as polycarbonate, and is the cheaper option [1,7]. The shields can be treated with coatings to impart anti-glare, anti-static, and anti-fogging properties [1]. The length varies from midface to the neck, and the width should reach at least to the point of the ear (recommendation from Centers for Disease Control and Prevention) to reduce the likelihood a splash going around the edge to reach the eyes. Crown and chin protection is recommended for improved infection control purposes [1]. This will reduce the risk of possible ocular inoculation. There is less retained dermal facial heat, less fogging compared to goggles, can be worn concurrently with other eye PPE, less claustrophobic and can be disinfected easily. It is inexpensive. However some may not fit over certain respirators. Industrial face shields, in the event of face shield shortages tend to be more expensive, heavier and bulkier.

Droplet vs. Aerosol

The new β-coronavirus belonging to the subgenus botulinum of Coronaviridae is a chimeric virus between a bat coronavirus and a coronavirus of unknown origin [8,9]. Respiratory droplets (5-50 µm) is the main route of transmission, which is affected by gravity, and may cause direct transmission via close contact (including the conjunctivae), or via surface contamination [10-19]. SARS-nCoV-2 can remain infectious on inanimate surfaces at room temperature for up to 9 days [20].

It is highly contagious and can be transmitted via smaller aerosols with a droplet nuclei ≤ 5µm, which can travel long distances and remain airborne for 2-4 hours, depending on the ambient conditions (temperature, humidity and ventilation) [21-23]. The size and number of droplets produced is dependent on exhalation velocity (higher velocity results in finer and greater droplets) [21]. The particle size determines the location in the respiratory tract it is deposited when it is inhaled [21,23]. Large droplets (> 5 µm) rapidly fall to the ground when produced by coughing or sneezing [21]. Certain events (eg coughing or sneezing, cardiopulmonary resuscitation) and aerosol generating procedures (AGP) (eg intubation, tracheostomy) can generate aerosols composed of smaller virus containing particles suspended in air [18].

Modelling of droplet sizes of less than 60 µm can travel more than 2 meters, with reports up to 8 meters [24]. Droplets produced during coughing and sneezing travel a meter from the mouth, and some may travel as far as 3 meters away but the amount of virus is lower the further away [25]. During a cough, droplets of airway secretions become air borne and is expelled from the mouth in a high velocity aerosol plume [25]. The aerosol droplets generated during coughing span a broad size range, and dispersion in the environment depends on the size: Smaller aerosol may remain airborne and spread throughout the room, while larger droplets may settle onto surfaces, impact on the face/eyes [25]. The droplet size is dynamic and changes during its transit from the respiratory tract to the environment with evaporation, and a large droplet can become an airborne particle in less than a second [24]. This is dependent on the type of aerosol generating procedure, temperature, relative humidity, ventilation and air exchanges in the environment [24]. Aerosolised viable SARS-CoV-2 virus has been be detected in the air up to 3 hours after [26]. However, infection is not neatly separated into the dichotomy of droplet versus air borne transmission route [27,28]. There is heterogeneity of the viral load between patients and the quantity of aerosol particles generated [23,25].

The Risk

Splashes

There is an overall 22.3-76.9% risk of contamination from blood and body fluid splash on protective eye shields during surgery [2,29-35]. The risk depends on the type of surgery, proximity to the operative field, type of diathermy used, and is proportional to the length of procedure and intra-operative blood loss. Depending on the type of surgery, mask with visors may not protect adequate protection [36]. Sing VK, et al. Reported contamination of both the surgeon's and assistant's face during orthopaedic surgery [36]. Chong, et al. Mathematical models have shown that prescription glasses a lone prevents splashes: 100% laterally, 92.6% medially, 77.8% inferiorly and 0% superiorly [37]. Lateral contamination has been reported to occur in 5% [31]. Many HCW erroneously believe that prescription glasses is adequate protection. Many studies have found contamination on the inner surfaces of prescription glasses, with contamination rate higher in longer surgeries (> 30 minutes) [6]. Conjunctival contamination has been found in 83% of prescription glasses and no protection, 50% for surgical loupes, 30% of facemask with visor, 17% for hard plastic glasses, and 3% of disposable plastic glasses during simulation of splashed debris during orthopaedic surgical procedures [38]. This represents a potential route of infection especially during surgery on the upper aerodigestive tract, where the SARS-n CoV-2 viral load is potentially high.

Droplets and aerosols

Viral transmission via eye contamination is very low but it exists. The first reported hepatitis B case via conjunctiva was reported in 1973 [6]. In 1982, herpesvirus 1 (B virus) was inoculated directly on the conjunctival mucosa in a chimpanzee resulted in its transmission [39]. In Bischoff WE, et al. Model, high rates of transocular transmission of live attenuated in fluenza virus was found in patients, likely via the nasolacrimal duct [40]. Aerosolised virus in surgical plume has been reported to cause iatrogenic infections. Human papillomavirus has been detected in laser plume, and has been reported to cause laryngeal papillomatosis in surgeons [41]. Aerosolised blood generated by high speed rotating instruments and electric coagulator has been found to travel according to the anticipated aerial current generated by the central air conditioning system in the operating room [42]. Shoham S, et al. Modelling found that surgical mask with visor, as well as safety eyeglasses with respirator resulted in eye contamination with oil-based fluorescent dye, whereas the full face shield did not [43]. Loveridge JM, et al. Demonstrated that the mask visor in the inverted position conferred better protection to the face [44]. Weber RT, et al. Study of PPE contamination found PPE contamination, including the face shield during simulated AGPs and close contact with patients [5]. The mask under the face shield was contaminated in 4% of the trials [5]. They also found that generation of infectious aerosol was not limited to AGPs but during routine care [5]. Lindsley WG, et al. Simulation has found that the use of face shield, and increasing the distance between the coughing source significantly reduced the amount of cough aerosol inhaled ($p < 0.001$).

It also reduced the amount of viable virus on the respirator by 70% [25]. The amount of virus deposited on the outer layer of respirator was significantly less ($p < 0.001$) [25]. Use of face shield only caused a modest decrease in the inhalation of air borne particles over the long term [25]. In the first 5 minutes after a cough, the amount of virus on the respirator was 96% lower when a face shield was worn [25]. After 30 minutes, the amount of virus collected when the face shield was worn was reduced by 81%, likely because smaller particles are able to float around it and accumulate over time [25]. It was also less effective a gainst the small-particle cough aerosol with 68% reduction of virus deposition as small particles are better able to travel around the face shield and be in haled [25]. The use of goggles in addition to gown and mask has resulted in a reduction of nosocomial RSV infection from 43% to 6% in admitted children, and 38% to 5% in staff [45]. Inconsistent use of gown, cap and goggles were strongly associated with SARS transmission [46]. Suboptimal adherence to wearing a face shield during aerosol generating procedures (AGP) was significantly ($p < 0.001$) and independently (OR 3.56, 95% CI 1.18-10.69) associated with acquiring an influenza-like illness while working on a ward with influenza A and B patients during peak in fluenza season [47] This wassignificant even after adjusting for possible household contacts.

One of the expert taskforce who visited Wuhan developed COVID-19 despite fully gowned with protective suit and the N95 respirator [12]. His first symptom was unilateral conjunctivitis [12]. In addition, van Doremalen N, et al. Modelling reported viability of SARS-CoV-2 in aerosols [26]. Some authors reported the lack of its presence in air samples obtained from rooms of hospitalised patients with COVID-19 may provide contradictory evidence regarding the extent of aerosol transmission [48,49]. However, another study contradicted this by finding environmental contamination a metre away from a COVID-19 positive 6-month old patient whose only contact is HCW in full PPE [50].

Awareness

HCW often do not detect contaminations, with reports of 85%-100% of the time [32,34,35,42,51,52]. HCW do not routinely use face shield if they consider the procedures to be un likely to be associated with potential contamination [2,53]. Traditionally surgeons have not worn eye protection as this is thought to influence vision through the eyepiece of the microscope, discomfort, fogging, reflection and refraction of light, routine lack of availability of eye/face protection, spectacles not fitting under protection, or the feeling that their own spectacles provide adequate protection [2,30,37,53,54]. These may not be a significant problem with face shield. Chong S, et al. Study reported that 26.8% of the surgeons admitted to have splash into their eyes, and only 8.5% sought testing for disease transmission, suggesting that despite 98.5% of the study population awareness of conjunctival blood s plash as a route of disease transmission, it is not respected [37].

Conclusion

Transmission of virus is multi-modal. Conjunctival mucosa presents a real risk for transmission in blood splashes, droplets or aerosols with viable virus, including SARS-CoV-2. HCW often do not detect contaminations to the eye resulting in low compliance of eye protection due to perceived low risk and erroneous belief that prescription glasses is adequate protection. However, modelling and simulation have shown importance of the face shield use in droplet precaution. While it is hard to be tested in isolation as it is part of the package of PPE used in droplet precaution, the limited reports from SARS, COVID-19 and in fluenza season supports its use.

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Conflict of Interest

None to declare.

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