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ZNAČAJ BIOAEROSOLA U STOMATOLOŠKOJ PROTETICI

BIOAEROSOL IN DENTAL PROSTHODONTICS

Marija G. Jovanović

UNIVERZITET U NIŠU,MEDICINSKI FAKULTET , PREDMET STOMATOLOŠKA PROTETIKA, STUDENT DOKTORSKIH STUDIJA, NIŠ, SRBIJA

UNIVERSITY OF NIŠ, FACULTY OF MEDICINE, DEPARTMENT OF PROSTHODONTICS, PHD STUDENT, NIŠ, SERBIA

Sažetak

Uvod: *U toku mnogih stomatoloških intervencija, koje se sprovode primenom ručnih nasadnih instrumenata i pustera, stvara se aerosol, koji se mešanjem sa česticama različitih organskih komponenti iz usne duplje pacijenta pretvara u bioaerosol (BIOA). Kada se visoko turažna mašina pokrene vazduh postaje trenutno kontaminirani praktično obuhvata čitavu prostoriju. Zagađenje se registruje za sve vreme, kao i posle protetskog tretmana.*
BIOA stvoren za vreme protetskog rada sadrži različite bakterije, gljivice i viruse iz usne duplje pacijenta. Ti mikroorganizmi predstavljaju realnu opasnost po zdravstvene radnike i potencijalni su rizik za nastanak infekcije.
Najčešći patogeni uzročnici uključuju viruse prehlade i gripa, herpes viruse, kao i patogene streptokoke i stafilokoke. Zarazne bolesti, biosinoze, akutne toksične reakcije, alergije, atopijske bolesti, konjuktivitis, kontaktni dermatitis iinfekcije respiratornog sistema, pa čak i neke vrste raka, moguće su manifestacije neželjeno gdejstva BIOA.
Zaključak: *BIOA predstavlja potencijalnu opasnost za kontaminaciju vazduha, radnih površina i predmeta u stomatološkim ordinacijama.*
Direktna i indirektna izloženost BIOA celokupnog stomatološkog osoblja i pacijenata posebno dolazi do izražaja u uslovima COVID-a 19. Iako je nemoguće u potpunosti eliminisati rizik od negativnog dejstva BIOA, od velikog je značaja obratiti pažnju na sve mere prevencije koje mogu smanjiti verovatnoću kontaminacije.

Ključne reči*: bioaerosol, kontaminacija, stomatološko osoblje*

Corresponding author:
Marija Jovanović DDM,PhD, Student,
Nemanjića Blvd. 61/9 18000 Nis, Serbia
Mobile: +381655214411
E-mail: jovanovicgmarija94@gmal.com

Abstract

Introdution: *During many dental interventions, performed using handpiece instruments and pusters, an aerosol is created,which is converted into a bioaerosol (BIOA) by mixing with the particles of various organic components from the patient's oral cavity.When the high-speed mashine is started, the air becomes instantly contaminated and practically covers the entire room. Pollution is registered all the times, as well as after prosthetic treatment.*
BIOA created during prosthetic workcontains various bacteria, fungi and viruses from the patient's oral cavity. These microorganisms pose a real hazard to health workers and are a potential risk for infection.
The most common pathogens include influenza viruses, herpes viruses, as well as pathogenic streptococci and staphylococci. Infectious diseases, biosynosis, acute toxic reactions, allergies, atopic diseases, conjunctivitis, contact dermatitis, infections of the respiratory system, and even some types of cancer, are possible manifestations of side effects of BIOA.
Conclusion:*BIOA poses a potential danger to contamination of air, work surfaces and objects in dental offices.*
Direct and indirect exposure of dental staff and patients to BIOA is especially pronounced in the conditions of COVID 19. Although it is impossible to completely eliminate the risk of adverse effects of BIOA, it is important to pay attention to all prevention measures that can reduce the likelihood of contamination.

Key words: *bioaerosol, contamination, dental staff*

Pojam i izvori bioaerosola

Veliki broj stomatoloških intervencija sprovodi se primenom ručnih nasadnih instrumenata (visokoturažne turbine, ultrazvučni skaleri, hirurški kolenjaci i nasadnici) i pustera, koji prilikom rada koriste vodu ili fiziološki rastvor pod pritiskom. Usled mešanja tečnosti i vazduha, stvara se i rasprskava u okolinu manja ili veća količina vodenih čestica (kapljica) u vidu aerosola. Tako sestvoreni aerosol mešasa česticama različitih organskih komponenti koje čine sadržaj usne duplje pacijentai pretvara u bioaerosol (BIOA). BIOA se definiše kao skupčesticaprečnika manjeg od 50 μм,koje sadrže mikroorganizme i imaju sposobnost dužeg vremenskog opstanka u vazduhu, pre nego se slegnu na površinu okoline[1,2]. Čestice u vazduhu počinju postepeno da isparavaju, što rezultira smanjenjem njihovog prečnika[1]. Čestice prečnika od1 μм do 5 μм nazivaju su jezgra kapljice, ačestice prečnika većeg od5 μм nazivaju se kapljice[3]. Što je prečnik čestica BIOA manji, predstavljaće veći rizik za terapeuta. Tako su čestice prečnika ispod 1 μм potencijalno najrizičnije, jer udisanjem aerosolizovanih mikroorganizama, vrlo lako prolaze alveole pluća, čiji je prečnik oko 5 μм i manji[4,5].Važno je napomenuti da se BIOA stvara i kada se nasadni instrumenti koriste bez vode. Harreli sar.[6] dokazali su da se kapljice BIOA formiraju u značajnoj količini od male količine tečnosti, koja je *in vitro* ostavljana kako bi simulirala pljuvačku.

Izvor BIOA u stomatološkim ordinacijama može biti oprema koja se svakodnevno koristi, to mogu biti i vodovodne cevi, preko biofilma kolonizovanih mikroorganizama nanjihovim unutrašnjim površinama[7,8,9]. Zdravstveni radnici, kao i pacijenti, kijanjem i kašljanjem, razgovorom i disanjem, raspršuju u okolinu čestice nazofaringealnog sekreta i pljuvačke pomešane sa mikroorganizmima. Kada neko kine napravi dva problema: prvo, izbaci veće kapljice, koje se rasprše na malu udaljenost i drugo, aerosolizovane čestice mikro-organizama duže ostaju u vazduhu. Na kraju, ventilacioni i klima uređaji mogu da utiču nastvaranje i distribuciju BIOA u širem vazdušnom prostoru stomatoloških ordinacija. Često se u filterima ovih uređaja, i pored redovnog čišćenja i održavanja, taložе i u dužem vremenskom periodu zadržavaju mikroorganizmi, koji se lako, aktiviranjem aparata, aerosolizuju u okolinu.

Concept and sources of bioaerosols

A large number of dental interventions are performed using handpiece instruments (high-speed turbines, ultrasonic scalers, surgical drills and low-speed handpieces) and air/water syringewhich use water or saline under pressure during operation. Due to the mixing of liquid and air, a smaller or larger amount of water particles (drops) in the form of an aerosol is created and dispersed into the environment. The aerosol thus created mixes with the particles of various organic components that make up the contents of the patient's oral cavity and turns it into a bioaerosol (BIOA). BIOA is defined as a set of particles with a diameter of less than 50 μm that contain microorganisms and have the ability to survive in the air for a long time, before settling on the surrounding surface[1, 2]. Particles in the air begin to gradually evaporate, resulting in a decrease in their diameter[1]. Particles with a diameter of 1 to 5 μm are called droplet nuclei, and larger than 5 μm are called droplets [3].The smaller particle diameter of the BIOA, the greater the risk for the therapist. Thus, particles with a diameter below 1 μm are potentially the most risky for inhalation of aerosolized microorganisms because they easily pass through the alveoli of the lungs with a diameter of about 5 μm and less[4,5]. It is important to note that BIOA are also created when handpieces are used without water.Harrel et al. [6], proved that BIOA droplets are formed in a significant amount from a small amount of fluid left *in vitro* to simulate saliva.

The source of BIOA in dental offices can be equipment that is used daily, as well as water pipes, through biofilm of colonized microorganisms on their inner surfaces[7, 8, 9]. Healthcare workers, as well as patients, by sneezing and coughing, talking and breathing, spray into the environment particles of nasopharyngeal secretion and saliva mixed with microorganisms. When someone sneezes he or she makes two problems. First, it expels larger droplets that are dispersed over a short distance, and second, aerosolized particles of microorganisms stay in the air longer. Finally, ventilation and air conditioners can influence the creation and distribution of BIOA in the wider airspace of dental offices. Often, despite regular cleaningand maintenance, microorganisms deposited and retainedin these devices and filters over a longer period of time easily get aerosolized into the environment by activating the appliance.

Sastav bioaerosola

Na sastav, koncentraciju i distribuciju BIOA utiču brojni faktori kao što su: vrsta i dužina trajanja stomatološkog tretmana, veličina i lokacija stomatološke ordinacije, broj stomatoloških jedinica, način lečenja, karakteristike i opšte zdravstveno stanje pacijenta, kao i sezonalnost godišnje doba[10].

BIOA stvoren za vreme stomatološkog tretmana sadrži različite saprofitne bakterije i gljivice iz usne duplje pacijenta, koje, kada promene sredinu i završe u sluzokoži respiratornog trakta zdravstvenog osoblja, mogu da ispolje patogena svojstva. Međutim, pacijenti mogu biti značajni nosioci i patogenih bakterija (*Staphylococcus aureus*) i virusa (*CoV-2, HIV, VHB iVHC*), koji, preko BIOA, predstavljaju visok rizik od kontaminacije. Dijametar bakterija (dužina od 0,3 μmdo 20 μm, prečnik od 0,5 μmdo 2,0 μm) i virusa (prečnik oko 0,1μм) izuzetno je mali. Pored mikroorganizama, BIOA sadrži i druge organske i neorganske komponente, kao što su: pljuvačka pacijenta, opiljci brušenih zuba, delovi amalgamskih i kompozitnih ispuna, dentalni plak, čestice ulja za podmazivanje rada nasadnih instrumenata, krv, nazofaringealni sekret, kao i ćelije mekog tkiva ledirane gingive gingivalnog sulkusa, koji se često povređuje prilikom subgingivalne preparacije zuba[1]. Sivakumar i sar.[11] navode da prilikom brušenja zuba rotacionim nasadnim instrumentima dolazi do oslobađanja brojnih čestica silicijuma i kompozitnih ispuna, kao i nusprodukata gorućih materija veličine od 2 μmdo 30 μм, što znači da spadaju u čestice opasnog opsega od 2,5 μм.

Za prikupljanje i identifikaciju mikro-organizama, danas se najčešće primenjuju dve metode: aktivna –Andersenovim uzorkom i pasivna –pomoću Petrijevih šolja sa agarima (soptični i krvni)[3]. Pumpom za uzorkovanje, vazduh iz okoline može sevrlo jednostavno usisati u ploče sa agarima. Hallier i sar.[12] ili se ploče sa agarima samo postavljaju na određenu udaljenost od izvora BIOA, tako da su izložene njegovom direktnom dejstvu[13].

Blizu izvora BIOA aerobne i anaerobne bakterije najčešće su podjednako zastupljene, dok se sa povećanjem udaljenosti taj odnos menja u korist aerobnih bakterija, što ukazuje na njihovo nedentalno poreklo[14].

Egusa[15] navodi da su patogeni mikro-organizmi (*Staphylococcus aureus, Actinobacterbaumanii, Capnocytop-hagaspecies, Actinobacillus species, Streptococcus Viridans, Morganellamorganii*)

Composition of bioaerosol

The composition, concentration and distribution of BIOA are influenced by numerous factors such as: type and duration of dental treatment, size and location of dental practice, number of dental units, method of treatment, characteristics and general health of the patient, as well as seasonality [10].

BIOA created during dental treatment contains various saprophytic bacteria and fungi from the patient's oral cavity, which when they change the environment and end up in the mucous membrane of the respiratory tract of health care staff, can exhibit pathogenic properties. However, patients can be significant carriers of both pathogenic bacteria (*Staphylococcus aureus*) and viruses (*CoV-2, HIV, VHB, and VHC*) that pose a high risk of contamination through BIOA. The diameter of bacteria (length 0.3 to 20 μm, diameter 0.5 to 2.0 μm) and viruses (diameter about 0.1 μm) is extremely small. In addition to microorganisms, BIOA also contains other organic and inorganic components such as: patient saliva,shavings of ground teeth, parts of amalgam and composite fillings, dental plaque, oil particles for lubrication of handpiece instruments, blood, nasopharyngeal secretions, as well as soft tissue cells of the led gingiva from gingival sulcus, which is often injured duringsubgingival tooth preparation[1]. Sivakumar et al. [11] state that when grinding teeth with rotary handpiece instruments, numerous particles of silicon and composite fillings are released, as well as by-products of combustible substances with a size of 2 to 30 μm, which means that they belong to particles with a dangerous range of 2.5 μm.

Today, two methods are most often used for collecting and identifying microorganisms: active, Andersen's sample and passive, using Petri dishes with agar (soptic and blood)[3]. With the sampling pump, environment air can be very easily sucked into agar plates [12]. Or the agar plates are only placed at a certain distance from the BIOA source, so that they are exposed to direct effects[13].

Near the source of BIOA, aerobic and anaerobic bacteria are usually equally represented, while with increasing distance, this ratio changes in favor of aerobic bacteria, which suggests their non-dental origin[14]. Egusa[15] states that pathogenic microorganisms (*Staphylococcus aureus, Actino-bacterbaumanii,Capnocytophaga species,*

pronađeni u otiscima nakon brušenja zuba i mogući su činioci BIOA. Iz uzoraka vode i vazduha izolovani su potencijalni uzročnici infekcije (*Pseudomonas, Micrococcus, Staphylococcus, Alternaria, Cladosporium, Penicillium, Aspergillus, Paecilomyces*)[16]. Ricci i sar. prikazuju pacijentkinju sa teškim oblikom respiratornog distresa izazvanog bakterijskom infekcijom (*Legionella pneumophila*), koja je bila zaražena u stomatološkoj ordinaciji za vreme tretmana visokoturažnom turbinom[17], dok Atlas i sar.[18] opisuju vrlo težak oblik pneumonije sa smrtnim ishodom kod stomatologa zaraženog preko BIOA (*Legionella dumoffi*).

Jedna opsežna metaanaliza, proistekla iz sedamnaest studija, analizirala je mikrobni sastav u stomatološkim klinikama i pri tom kumulativno identifikovala[19] bakterija (*Acinetobacter wolffii, Legionella spp, Pseudomonas aureus, Staphylococcus aureus, Staphylococcus capitis, Staphylococcus chromogenes, Micrococcus luteus, Diphteroids, Staphylococcus lentus, Staphylococcus haemolyticus, Micrococcus spp, Corynebacteria, Staphylococcus xylosus, Staphylococcus epidermidis, Micrococcus lylae, Bacillus spp, Staphylococcus fominis, Bacillus pumilus, Actinomycetes*) i [23] gljivice (*Alternaria alternate, Aspergillus flavus, Cladosporium cucumerinum, Geotrichum spp, Stemphylium spp, Alternaria brassicicola, Aspergillus fumigatus, Cladosporium ramotenellum, Monocillim indicum, Stemphylium spp, Alternaria citri, Aspergillus niger, Cladosporium sphaerospermum, Monodictys glauca, Ulocladium alternariae, Arthrinium phaesospermum, Botrytis spp, Cladosporium spp, Pencillium spp, Aspergillus, Cladosporium cladosporiodias, Cladosporium spongiosum, Penicillium chrysogenum*) poreklom iz vode, ljudske kože i usne duplje, koje se mogu naći u BIOA[3].

Ipak, smatra se da najveći deo BIOA (74% – 100%) čine gram pozitivne koke (*Staphylococcus epidermidis* i *Micrococcus*), dok ostatak predstavljaju gram pozitivne bakterije u obliku štapića i one koje stvaraju endospore, kao i neporozne bakterije (*Cladosporium i Penicillium*)[19].

Sumnja se da BIOA sadrži mnogo virusa. Međutim, podaci o unakrsnoj infekciji virusima u potpunosti nedostaju, verovatno zbog ograničenih dostupnih metoda za molekularno tipiziranje virusa[20].

Actinobacillus species, Streptococcus Viridans, Morganellamorganii) were found in the impressions after tooth preparation and are possible factors in BIOA. Potential causes of infection (*Pseudomonas, Micrococcus, Staphylococcus, Alternaria, Cladosporium, Penicillium, Aspergillus, Paecilomyces*) were isolated from water and air samples[16]. Ricci et al. show a patient with severe respiratory distress caused by a bacterial infection (*Legionella pneumophila*) that occurred in a dental office during treatment with a high-speed turbine[17], while Atlas et al.[18] describe a very severe form of fatal pneumonia in a dentist infected with BIOA (*Legionella dumoffi*).

One extensive meta-analysis, derived from seventeen studies, analyzed the microbial composition of dental clinics and cumulatively identified[19] bacteria (*Acinetobacterwolffii, Legionella spp, Pseudomonas aureus, Staphylococcus aureus, Staphylococcus capitis, Staphylococcus chromogenes, Micrococcus luteus, Diphteroids, Staphylococcus lentus, Staphylococcus haemolyticus, Micrococcus spp, Corynebacteria, Staphylococcus xylosus, Staphylococcus epidermidis, Micrococcus lylae, Bacillus spp, Staphylococcus fominis, Bacillus pumilus,Actinomycetes*) and[23] fungi (*Alternaria alternate, Aspergillusflavus, Cladosporiumcucumerinum, Geotrichumspp, Stemphyliumspp, Alternariabrassicicola, Aspergillusfumigatus, Cladosporium-ramotenellum, Monocillimindicum, Stemphyliumspp, Alternariacitri, Aspergillusniger, Cladosporiumsphaerospermum, Monodictysglauca, Ulocladiumalternariae, Arthriniumsphaerospermum, Botrytis spp, Cladosporiumspp, Pencilliumspp, Aspergillus, Cladosporiumcladosporiodias, Cladosporiumspongiosum, Penicilliumchrysogenum*) originating from water, human skin and oral cavity which can be found in BIOA[3].

However, most BIOAs (74-100%) are thought to be gram-positive cocci (*Staphylococcus epidermidis* and *Micrococcus*), while the remainder are gram-positive bacilli and endospore-forming bacteria as well as non-spore bacteria (*Cladosporium*and *Penicillium*)[19].

BIOA is suspected to contain many viruses. However, data on crossinfection with viruses are completely lacking, probably due to the limited methods available for molecular typing of viruses[20].

Koncentracija i rasprostranjenost

Kada se visokoturažna turbina pokrene, vazduh postaje trenutno kontaminiran i praktično obuhvata čitavu prostoriju[21]. Najveće zagađenje registruje se tokom samog protetskog tretmana, da bi se značajno smanjilo na kraju intervencije[22,23]. Na završetku radnog dana, kontaminacija vazduha smanjuje se za 50% – 70% u svim oblastima[24]. Zagađenje vazduha direktno je proporcionalno broju primljenih pacijenata u toku dana[25]. Rautemaa i sar.[21] navode kontaminaciju radne prostorije streptokokama i stafilokokama,na svim udaljenostima od mesta izvora BIOA, kada su se koristili nasadni instrumenti velike brzine u odnosu na stomatološke intervencije prilikom kojih se takvi instrumenti nisu koristili.

Najveća koncentracija BIOA uglavnom se registruje u glavnom području tretmana[11,24]. Dodavanje fluorescentnog kontrastnog sredstva u vodu,koju koristi nasadni instrument, pokazalo je najveću koncentraciju čestica BIOA u predelu glave stomatologa, zatim na nadlaktici, vratu i grudnom košu[25]. Kada govorimo o izloženosti lica stomatologa, najviše je kontaminirano područje nosa i najviše su kontaminirani unutrašnji uglovi očiju, dok je zigomatični predeo najmanje kontaminiran[26]. Interesantno je toda isti autori nisu uočili značajnu razliku u kontaminaciji desne i leve strani lica[25]. Sa povećanjem udaljenosti od mesta izvora BIOA, broj formiranih bakterijskih kolonija po kvadratnom centimetru postepeno sesmanjuje[27,28], ali se njihovo evidentno prisustvo može registrovati i na udaljenosti od 1 m do 1,5m[14,29]. Virusi su mnogo manji od bakterija i verovatno se znatno lakšeprenose u okolinu[20], dostižući veće udaljenosti od tačke svog izvora[14]. Čestice BIOA nekada mogu i satima da opstanu u vazduhu, predstavljajujući realnu opasnost po zdravstvene radnike i potencijalni rizikza nastanak infekcije. Na kretanje BIOA veliki uticaj može imati strujanje vazduha, prouzrokovano primenom ventilatora i klima uređaja za vreme stomatološkog tretmana, tako da se čestice mogu naći i u udaljenim područjima prostorije. Sleganje čestica BIOA na obližnje površine i kontaminacija istih predstavlja potencijalni rizik za prenos transmisionih bolesti (hepatitis B i C, AIDS)[25,30].

Concentration and distribution

When the high-speed turbine is started, the air becomes instantly contaminated and practically covers the entire room[21]. The greatest pollution is registered during the prosthetic treatment itself, to be significantly reduced at the end of intervention[22,23]. At the end of the working day, air contamination is reduced by 50-70% in all areas[24]. Air pollution is directly proportional to the number of patients admitted during the day[25]. Rautemaa et al.[21] indicate contamination of the working room, with streptococci and staphylococci, at all distances from the source site of BIOA when high-speed handpieces were used in relation to dental interventions when such instruments were not used.

The highest concentration of BIOA is mainly registered in the main treatment area[11,24]. The addition of fluorescent contrast agent to the water used by the handpiece showed the highest concentration of BIOA particles in the dentist's head, then on the upper arm, neck and chest[25]. When we talk about the exposure of the dentist's face, the area of the nose and the inner corners of the eyes are the most contaminated, while the zygomatic area is the least contaminated [26]. It is interesting that the same authors observed no significant difference in contamination of the right and left side of the face[25]. With increasing distance from the place of origin, BIOA number of formed bacterial colonies per square centimeter is gradually reduced[27,28], or their evident presence can be registered at a distance from 1 to 1.5 m[14,29]. Viruses are much smaller than bacteria and are probably much easier to transmit to the environment[20], reaching greater distances from their source[14]. BIOA particles can sometimes survive in the air for hours, posing a real hazard to health workers and a potential risk for infection.The movement of BIOA can be greatly influenced by the air flow caused by the use of fans and air conditioners during dental treatment, so that particles can be found in remote areas of the room. Sedimentation of BIOA particles on nearby surfaces and their contamination represent a potential risk for transmission of communicable diseases (hepatitis B and C, AIDS)[25,30].

Potencijalni problem

Kontaminacija i širenje infekcije u stomatološkoj ordinaciji posledica su: a) direktnog kontakta sa krvlju i pljuvačkom inficiranog pacijenta; b) kontakta sa instrumentima i radnim površinama, koje su neadekvatno očišćene, sterilisane i dezinfikovane i c) kontakta sa bioaerosolizovanim česticama prenetih vazduhom. Glavna ulazna mesta infekcije kod stomatologa, za vreme rada, su epiderm ruku, konjuktivalni epitel, oralni epitel, nazalni epitel, epitel gornjih disajnih puteva, epitel bronha i epitel plućnih alveola[31].

Usna duplja je anatomskiu vrlo bliskoj vezi sa gornjim partijama respiratornog sistema, tako da, osim pljuvačke, luči sekrete iz nosa, grla i disajnih puteva. Najčešći potencijalni patogeni uzročnici uključuju viruse prehlade i gripa, herpes viruse, virus SARS, kao i patogene streptokoke i stafilokoke[1]. Zato je BIOA realna pretnja po zdravlje stomatološkog osoblja i mogući je izvor infekcije[32,33]. Zarazne bolesti, biosinoze, akutne toksične reakcije, alergije, atopija i atopijske bolesti, interakcije BIOA sanebiološkim agensima, pa čak i neke vrste raka, moguće su manifestacije neželjenog dejstva BIOA[34]. Permanentni nadražaj respiratorne sluzokože može biti uvod za nastanak alergijskog rinitisa, bronhijalne astme i hroničnog bronhitisa. Ipak, najčešće se javljaju konjuktivitis, kontaktni dermatitis i infekcije respiratornog sistema[26,35,36]. Izloženost BIOA predstavlja veliku opasnost i za pacijente, naročito one sa imuno-kompromitovanim zdravljem[3,21].

Sa najnovijom pojavom korona virusa 2019-CoV-2 (0,06μм–0,14μм), koji izaziva COVID-19 i pratećeg respiratornog sindroma, opasnost od kontaminacije i širenja infekcije putem BIOA dobija planetarni značaj. Stomatološka profesija je posebno na udaru, tako da je u mnogim zemljama svedena na minimum i praktično prestala sa radom, osim u slučaju hitnih intervencija, koje su sprovođene uz rigorozne mere zaštite.

Mere prevencije

Hirurška maska

Hirurška maska imanizak nivo filtriranja i propustljivost od ≥2 μм. Nosi je stomatolog i služi za zaštitu pacijentaod lekara. Ne prijanja u potpunosti uz lice, tako da BIOA može da prođe oko maske.

Potential problem

Contamination and spread of infection in the dental office is a consequence of: a) direct contact with the blood and saliva of an infected patient, b) contact with instruments and work surfaces that are inadequately cleaned, sterilized and disinfected, and c) contact with bioaerolysed airborne particles. The main entry points for dental infection during treatment are the epidermis of the hand, the conjunctival epithelium, the oral epithelium, the nasal epithelium, the epithelium of the upper respiratory tract, the epithelium of the bronchi, and the epithelium of the pulmonary alveoli[31].

The oral cavity is anatomically very closely related to the upper parts of the respiratory system, so that, in addition to saliva, it secretes secretions from the nose, throat and respiratory tract. The most common potential pathogens include influenzaviruses, herpes viruses, SARS virus, as well as pathogenic streptococci and staphylococci[1]. Therefore, BIOA is a real threat to the health of dental staff and is a possible source of infection[32,33]. Infectious diseases, biosynosis, acute toxic reactions, allergies, atopy and atopic diseases, interactions of BIOA with non-biological agents, and even some types of cancer, are possible manifestations of side effects of BIOA[34].Permanent irritation of the respiratory mucosa may be an introduction to the development of allergic rhinitis, bronchial asthma and chronic bronchitis. However, conjunctivitis, contact dermatitis and infections of the respiratory system occur most often[26,35,36]. BIOA exposure is a major risk for patients, especially those with immunocompromised health[3,21].

With the latest appearance of coronaviruses 2019-CoV-2 (0.06-0.14μm) causing COVIDE-19 and related respiratory syndrome, the risk of contamination and the spread of infection through BIOA receives planetary importance. The dental profession is particularly vulnerable, so that in many countries it has been reduced to a minimum and practically stopped working, except for emergency interventions, which were carried out with rigorous protection measures.

Prevention measures

Surgical mask

A surgical mask has a low level of filtration and permeability of ≥2 μm. It is worn by a dentist and serves to protect the patient from the doctor.

Nije efikasna zaštita od bakterija i, naročito, virusa, jer sitne čestice mogu da prođu kroz materijal od kogaje napravljena. Ako je nosi zaraženi pacijent, maska sprečava kontaminaciju njegove okoline. Nosi se najduže od 3 do 8 sati, jer pri ekspirijumu nastaje kondenzacija vlage na unutrašnosti maske. Služi za jednokratnu upotrebu.

Rautemaai sar.[21] navode podatak da su maske bile statistički značajno bakterijski kontaminirane stvorenim BIOA tokom upotrebe rotirajućih nasadnih instrumenata velike brzine, nakon seanse lečenja od 40 minuta. Druga studija odnosi se na održivost patogenih mikroorganizama, poreklom iz BIOA, u materijalima za filtriranje, od kojih se izrađuje zaštitna oprema (maske) u zavisnosti od količine akumulirane vlage i tipa mikroorganizama. Najpostojanijim pokazala se bakterija *Staphylococcus* aureus, zatim gljivica *Candida albicansi bakterija Escherichia coli, dok su bakterija Bacillus subtilisi gljivica Aspergillus* niger pokazali najmanju postojanost[37]. To znači da posle stomatološkog tretmana hirurška maska, kao potencijalni izvor zaraze, mora adekvatno da se skine sa lica i odloži na odgovarajuće mesto.

Respirator

Respiratorje sličan maski, ali je drugačije dizajniran. Ima visoke nivoe filtriranja i propustljivosti. Nosi ga stomatolog i služi za zaštitu lekara od pacijenta. U potpunosti prijanja uz lice, smanjujući prolazak BIOA oko respiratora. Može biti saventilom i bez ventila. Ventil se otvara pri ekspirijumu i omogućava lakše disanje, stvaranje manja kondenzacije vlagei sprečava zamagljivanje naočara. Međutim, ako je lekar bolestan, vazduh pri ekspirijumu prolazi kroz ventil ka pacijentu, što nije dobro. Može biti za jednokratnu i višekratnu upotrebu (filter se menja). Vrste respiratora:

a) P1 (FFP1) –propustljivost >0.3μм;kapacitet filtera 80%; propustljivost sa strane 22%;

a) N95 (KN95)–propustljivost >0.3μм; kapacitet filtera 95%; propustljivost sa strane 8%;
b) P2 (FFP2)–propustljivost >0.3μм; kapacitet filtera 94%; propustljivost sa strane 8%;
c) N99 (FFP3)– propustljivost >0.023 μм; kapacitet filtera 99%; propustljivostsa strane 2%;
d) N100 (P3) - propustljivost >0.02μм; kapacitet filtera 99,95% (P3) i 99,97% (N100).

It does not adhere fully to the face so that BIOA can pass around the mask. It provides no effective protection against bacteria and viruses in particular, because small particles can pass through the material from which it is made. If the infected patient wears a mask, it prevents contamination of the environment. It is worn for a maximum of 3 to 8 hours because expiration causes moisture condensing on the inside of the mask. It is indicated for single use only.

Rautemaa et al.[21] state that the masks were statistically significantly bacterially contaminated with the generated BIOA during the use of high-speed handpieces after a 40 min. treatment session. Another study refers to the viability of pathogenic microorganisms, originating from BIOA, in filter materials from which protective equipment (masks) are made, depending on the amount of accumulated moisture and the type of microorganisms.*Staphylococcus aureus* proved to be the most persistent, followed by the fungus *Candida albicans* and bacterium *Escherichia coli*, while *Bacillus subtilis* and *Aspergillusniger* showed the lowest persistence[37]. This means that after dental treatment, the surgical mask, as a potential source of infection, must be properly removed from the face and disposed of in an appropriate place.

Respirator

A respirator is similar to a mask but designed differently. It has a high level of filtration and permeability. It is worn by a dentist and serves to protect the doctor from the patient. Fully adheres to the face reducing the passage of BIOA around the respirator. It can be with or without valves. The valve opens during expiration and allows easier breathing, less moisture condensation and prevents fogging of the glasses. However, if the doctor is sick, the air during expiration passes through the valve to the patient, which is not good. It can be disposable and reusable (filter changes). Types of respirators:

a) P1 (FFP1) - permeability ≥0.3 μm, filter capacity 80%, side permeability 22%,
b) N95 (KN95) - permeability ≥0.3 μm, filter capacity 95%, side permeability 8%,
c) P2 (FFP2) - permeability ≥0.3 μm, filter capacity 94%, side permeability 8%,
d) N99 (FFP3) - permeability ≥0.023 μm, filter capacity 99% and side permeability 2%,
e) N100 (P3) - permeability ≥0.02 μm, filter capacity 99.95% (P3) and 99.97% (N100).

O efikasnosti respiratora i hirurških maski u literaturi postoje različiti podaci. Dok jedna *in vitro* studija ukazuje na superiornost filtracije respiratora (94% – 96%) u odnosu na hirurške maske (90% – 92% i 85% – 86%)[38], druga ukazuje na njihovu obostranu sličnu i ograničenu efikasnost[39]. Radonovich i sar.[40] nisu našli statistički značajnu razliku potvrđenih slučajeva influence između zdravstvenih radnika koji su nosili respiratore N95 (8,2%) i onih koji su nosili hirurške maske (7,2%).Isto tako, infekcija gripom registrovana je kod 23,6% medicinskih sestara koje su nosile hirurške maske u odnosu na 22,9% medicinskih sestara koje su nosile respiratore, što, opet, nije imalo statističku značajnost[41]. Obe *in vivo* studije rađene su u bolničkim uslovima. Kada se radi o stomatološkom osoblju (zdravstvena profesija visokog rizika) u uslovima COVID-19 pandemije, čini se razložnim da se prilikom intervencija, pri kojima se stvara velika količina BIOA,savetuje nošenje respiratora N95 (FFP2). Ukoliko se sumnja ili je potvrđena CoV-2 infekcija, rade se samo hitne intervencije, izbegava se primena instrumenata koji proizvode BIOA, uz nošenje respiratora N99 (FFP3) ili N100 (P3) i sprovode sesve ostale visoke mere zaštite.

Kada posle stomatološkog postupka lekar skine zaštitnu masku/respirator i nastavi boravak u istoj prostoriji, izlaže se potencijalnom riziku od negativnog dejstva BIOA, koji i dalje perzistira u vazduhu ili se klima uređajem širi po prostoriji.

Zaštitna kapa i mantil (kecelja)

Kapa služi za zaštitu kose, čela i ušiju od negativnog dejstva BIOA, dok se mantil koristi prilikom dugotrajnih stomatoloških intervencija (brušenje većeg broja zuba).

Vizir i naočare

Oči i konjuktiva su manje izloženi riziku od BIOA u odnosu na usta i nos, preko kojih se čestice direktno udišu u pluća. Vizir čini mehaničku barijeru stvorenom BIOA,ali je otvoren sa strane. Naočare mogu biti bočno otvorene i sa gumenim vazdušnim zaptivačem, što je bolja opcija. Vizir i naočare se mogu međusobno kombinovati i nose se uz zaštitnu masku/respirator.

There are different data in the literatureabout the effectiveness of respirators and surgical masks. While one *in vitro* study indicates the superiority of respiratory filtration (94-96%) compared to surgical masks (90-92% and 85-86%)[38] another, indicates their mutual similar and limited efficiency[39]. Radonovich et al.[40] did not find a statistically significant difference in confirmed cases of influenza between healthcare workers who wore N95 respirators (8.2%) and those who wore surgical masks (7.2%). Also, influenza infection was registered in 23.6% of nurses wearing surgical masks compared to 22.9% of nurses wearing respirators, which again had no statistical significance[41]. Both *in vivo* studies were performed in a hospital setting. In the conditions of COVID-19 pandemic, it is advisablethat the dental professionals (high risk medical profession) wear the respirator N95 (FFP2) during intervention, when a large amount of BIOA is dispersed. If CoV-2 infection is suspected or confirmed, only emergency interventions are performed, the use of instruments that produce BIOA is avoided, along with wearing a N99 (FFP3) or N100 (P3) respirator and all other high protection measures.

Whenthe doctor removes the protective mask/respirator, and continues to stay in the same room after the dental procedure, he or she is exposed to the potential risk of the negative effects of BIOA, which still persists in the air or spreads through the room with air conditioning.

Protective cap and coat (apron)

The cap serves to protect hair, forehead and ears from the negative effects of BIOA, while the coat is used during long-term dental interventions (preparationof a large number of teeth).

Visor and glasses

The eyes and conjunctiva are less exposed to the risk of BIOA in relation to the mouth and nose through which the particles are inhaled directly into the lungs. The visor forms a mechanical barrier to created BIOA but is open from the side.Glasses can be laterally open and with a rubber seal, which is a better option. Visor and glasses can be combined with each other and worn with a protective mask/respirator.

Large volume evacuator (sauger)

The use of these devices contributes to the rapid removal of large amounts of liquid

Evakuator (sauger) velike zapremine

Upotreba ovih aparata doprinosi brzom uklanjanju veće količine tečnog sadržaja usne duplje, iz kog nastaje BIOA i smanjuje zagađenje okoline za preko 90%[42].

Hlorheksidin (0,12%)

Preproceduralno ispiranje usta antiseptičkim rastvorom značajno smanjuje bakterijsku kontaminaciju BIOA[43,44].

Koferdam

Koferdam mehanički izoluje usnu duplju i njen sadržaj od spoljne sredine[1]. Nepogodan je kada se vrši protetski tretman velikog broja zuba.

Dezinfekcija radnih površina i prostorije između tretmana pacijenata

Ova metoda smanjuje mogućnost kontaminacije nataloženim aerosolizovanim mikroorganizama, kako stomatološkog osoblja, tako i pacijenata[21].

Zaključak

BIOA, koji se stvara za vreme stomatološkog tretmana, sadrži različite mikroorganizme (virusi, bakterije, gljivice) i predstavlja potencijalnu opasnost za kontaminaciju vazduha, radnih površina i predmeta u stomatološkim ordinacijama. Direktna i indirektna izloženost BIOA celokupnog stomatološkog osobljai pacijenata posebno dolazi do izražaja u uslovima COVID-19 pandemije. Iako je nemoguće u potpunosti eliminisati rizik od negativnog dejstva BIOA, od velikog je značaja sprovođenje svih mere prevencije koje mogu smanjiti verovatnoću zaraze.

content of the oral cavity from which BIOA is formed and reduces environmental pollution by over 90%[42].

Chlorhexidine (0.12%)

Pre-procedural rinsing of the mouth with an antiseptic solution significantly reduces bacterial contamination with BIOA[43, 44].

Rubber dam–A

Rubber dam mechanically isolates the oral cavity and its contents from the external environment [1]. It is unsuitable when performing prosthetic treatment of a large number of teeth.

Disinfection of work surfaces and room between patients

The method reduces the possibility of contamination from deposited aerosolized microorganisms of both dental staff and patients[21].

Conclusion

BIOA that is created during dental treatment contains various microorganisms (viruses, bacteria, fungi) and poses a potential danger to contamination of air, work surfaces and objects in dental offices. Direct and indirect exposure of dental staff and patients to bioaerosols is especially pronounced in the conditions of COVID 19. Although it is impossible to completely eliminate the risk of adverse effects of BIOA, it is important to pay attention to all prevention measures that can reduce the likelihood of infection.

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