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DENTAL BIOAEROSOL AS AN OCCUPATIONAL HAZARD IN A DENTIST'S WORKPLACE

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Abstract: Many-year studies on aerosols as an infection vector, despite their wide range, ignored dental aerosol. All procedures performed with the use of dental unit handpieces cause the formation of aerosol and splatter which are commonly contaminated with bacteria, viruses, fungi, often also with blood. Aerosols are liquid and solid particles, 50 µm or less in diameter, suspended in air. Splatter is usually described as a mixture of air, water and/or solid substances; water droplets in splatter are from 50 µm to several millimetres in diameter and are visible to the naked eye. The most intensive aerosol and splatter emission occurs during the work of an ultrasonic scaler tip and a bur on a high-speed handpiece. Air-water aerosol produced during dental treatment procedures emerges from a patient's mouth and mixes with the surrounding air, thus influencing its composition. Because air contained in this space is the air breathed by both dentist and patient, its composition is extremely important as a potential threat to the dentist's health. According to the author, insufficient awareness of health risk, working habits, and economic factors are the reasons why dentists do not apply the available and recommended methods of protection against the influence of bioaerosol and splatter. Behaviour protecting a dentist and an assistant from the threat resulting from the influence of dental aerosol cannot be limited to isolated actions. The author, on the basis of the literature and own research, characterizes bioaerosol and splatter in a dental surgery and reviews a full range of protective measures against these risk factors.

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INTRODUCTION

The dental unit is the main element of dental surgery equipment, being a multifunctional set of tools which enable a dentist to perform basic procedures. It consists of a dental chair, usually integrated with an instrument console, an operation lamp and a spittoon. According to international standards, a unit adapted to four-hand work with a patient in the supine position, has a minimum of 3 working handpieces for a dentist, i.e. a high-speed handpiece (turbine) a low-speed handpiece (microengine with straight and contra-angle handpieces) and a air-water syringe, as well as a minium of 3 handpieces for an assistant – two sucking handpieces (sucking device and saliva ejector) and an air-water syringe.

Dentist's working handpieces (below called "handpieces") are supplied with water through a system of thin plastic tubes which constitute dental unit waterlines (DUWL). Water cools the burs and scaler tips (an additional handpiece used to remove dental deposits) and rinses tissues during preparation. A stream of water and/or air produced by an air-water syringe is used during other therapeutic procedures. Two types of water circulation in dental unit waterlines may be distinguished by the water supply: 1) an open system where the source of water is a municipal water system, and 2) a closed system in which water is drawn from a container (reservoir) belonging to a unit.

Dental handpieces produce aerosol which is a mixture of air coming from a handpiece, water flowing from DUWL, and a patient's saliva, and is always accompanied by splatter.

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DENTAL BIOAEROSOL AND SPLATTER

All procedures performed with the use of dental unit handpieces cause the formation of aerosol and splatter which are commonly contaminated with bacteria, viruses, fungi, often also with blood [4, 11, 27, 32, 39].

Aerosols are liquid or solid particles, 50 µm or less in diameter, suspended in air. They can remain in air for a long time and be transported with air flows at long distances. They are capable of penetrating deep into the respiratory system, reaching as far as pulmonary alveoli [13, 21].

Splatter is usually described as a mixture of air, water and/or solid substances, such as fragments of dental fillings, carious tissues, sandblasting powder, etc. Water droplets in splatter are from 50 µm to several millimetres in diameter and are visible to the naked eye. They have sufficient mass and kinetic energy to move ballistically and quickly settle on objects due to the action of gravitation forces. Splatter shows limited penetration into the respiratory system. Splatter particles, moving along trajectories, can come into contact with the mucosa of nostrils, open mouth, eyes and skin. They are deposited on hair, clothes and in the immediate surroundings of the splatter source. The range of splatter is from 15 to 120 cm from a patient's oral cavity. Thus, splatter can easily reach a doctor and an assistant [17, 21].

The microflora of DUWL water and that of a patient's oral cavity exerts a decisive influence on the micorbiological composition of dental aerosol produced by unit handpieces [32, 35, 38].

Dental aerosols whose source is the patient include: saliva, nasal-and throat secretion, dental plague, gum secretion, blood, tooth tissues and materials used for dental treatment. Aerosol composition varies from patient to patient, depends on the site and type of procedure in the oral cavity (tooth preparation, polishing, dental deposits removal) [16].

The most intensive aerosol and splatter emission occurs during the work of an ultrasonic scaler tip and of a bur on a high-speed handpiece [3, 12, 17].

During conservative treatment and professional oral hygiene procedures, the sites showing the highest microbiological contamination due to aerosol and splatter are (in descending order): doctor's and assistant's masks, a unit lamp, surfaces close to spittoons, and mobile instrument-material tables. On the contaminated surfaces the following bacteria were found: bacteria of the *Streptococcus* genus, which constitute 42% of total bacteria, *Staphylococcus* – 41%, and Gram-negative bacteria – 17%. The differences in contamination between a doctor's mask and a table are significant for the first two genera [26].

Dental aerosol and splatter affect the microbiological quality of air in a dental surgery, and the factors forming dental aerosol exert an important influence on the composition of the surgery microflora [15]. Quantitative and qualitative studies on dental surgery air show that during procedures with the use of unit handpieces, there is a multiple increase in concentration levels of bacteria in air during work and immediately after it has been finished [1, 9, 18]. At the end of a working day, 30 minutes after treatment cessation, bacterial contamination levels decrease by 50-70% [1]. The microflora of air in a dental surgery contains *Staphylococcus epidermidis* – 37.1% of total bacteria, *Micrococcus* spp. – 32.6%, nondiphterial corynebacteria – 28.2%, *Staphylococcus aureus* – 0.6%, *Pseudomonas* spp. – 0.6%, and fungi – 0.9%. The presence of opportunistic microorganims (*Staphylococcus epidermidis*, non-diphterial corynebacteria, *Pseudomonas* spp.) is significant [9].

Osorio *et al.* [23] showed the prevalence of *Streptococcus* and *Staphylococcus* bacteria in the air of a dental surgery. Other studies indicate that 85-90% of these bacteria are *Streptococcus* bacteria typical for the oral cavity [3]. Researchers studying the microbiological condition of air in dental surgeries believe that this is one of the most dangerous contamination carriers in the working environment of a dentist. The contamination route involves, apart from inhalation of infectious particles, the fact that they remain (are suspended) in air, settle on surfaces and are reaspirated [9, 16, 18]. The researchers recommend simultaneous monitoring of the microbiological condition of air and removal of microbiological contaminated air from the rooms of dental surgeries.

The presence of blood or its components in dental aerosol is an important problem. Bennett *et al.* [3] claim that blood, containing large particles, cannot be blown out from the oral cavity, and does not necessarily take the form of aerosol. According to the author, everyday clinical practice shows that during work with dental unit handpieces, a doctor and an assistant are rather exposed to splatter or even to being accidentally splashed with blood as a result of an incorrect working technique.

There is a need to assess risks resulting from exposure to aerosol and splatter, both to patients and to dental personnel, and also to introduce methods to monitor aerosol and splatter. Many-year studies on aerosols as an infection vector, despite their wide range, ignored dental aerosol [6]. Own study results, as well as the scarce literature from recent years [11], indicate the need for examining this subject.

The composition of the air in a dentist's breathing space, contained between a dentist and a patient, is a problem entirely ignored in microbiological analyses of air in a dental surgery. Air-water aerosol produced during work with dental unit handpieces emerges from a patient's mouth and mixes with the surrounding air, thus influencing its composition. Because air contained in this space is the air breathed by both dentist and patient, its composition is extremely important as a potential threat to the dentist's health.

In own studies, the microbiological composition of DUWL water as the source of water fraction of aerosol was evaluated in parallel with the composition of dental aerosol as such. The author examined the air in a dentist's breathing space contaminated with aerosol produced during conservative treatment; all the studied samples showed microbiological contamination. Bacterial microflora of the air was – with regard to the number of the isolated aerobic or anaerobic species – more varied than in the samples taken from DUWL. In the air, bacterial endotoxin was also found in an amount exceeding the proposed safe value, which created a potential risk both for doctor and patient [35]. Among Gram-negative bacteria, *Ralstonia pickettii* rods, which probably came from DUWL [33], occurred most frequently. Bacteria of the genera: *Streptococcus mutans*/*ratti* and *Lactococcus lactis* ss *lactis*, characteristic for the human oral cavity [28], were the most numerous. In all the air samples, fungal microflora was present; however, its composition was different than in the DUWL samples [36]. No yeast-like fungi were found in the air, and the microflora was composed of the mould fungi usually present in the surrounding air [37].

The composition of the examined aerosol seems to confirm that the air-water stream ejected under pressure from a high-speed handpiece disperses microorganisms present in DUWL water and in the oral cavity to subsequently mix with microflora of the environment.

METHODS OF REDUCING EXPOSURE TO DENTAL AEROSOL

Study results, obtained both by the author and by other researchers, point to the importance of routine monitoring of micorbiological contamination of dental surgeries – the surface of instruments and devices, air and dental unit water, and – in the case of their contamination – the need for sterilization and disinfection. Apart from the universal sanitary and epidemiological procedures valid for dental surgeries, the following principles should be followed in order to reduce the risk resulting from the use of a dental unit and exposure to aerosol.

1. Water flowing from unit handpieces should meet the conditions for potable water. The quality of water should be monitored with the use of commercial laboratory tests, or sets which can be applied in a dental surgery, in order to determine the number of heterotrophic microflora in potable water [24, 25]. Various water decontamination methods may be used [31, 33, 34].

2. The correct maintenance of handpieces should follow the principle: "Do not disinfect when sterilization is possible". The principle points to the necessity for routine sterilization. Sterilization of handpieces ensures their internal and external sterility [8, 10], eliminating 1) patient-patient infection, and 2) contamination of waterlines with tissue fragments and micororganisms, inlcuding viruses, which was confirmed in tests with highly sensitive methods, such as PCR – polymerase chain reaction [19]. Because a destructive influence of steam sterilization after every use on the durability of handpieces was reported, disinfection between patients is acceptable [20]. However, it is indispensable to sterilize handpieces after a working day.

3. It is strictly necessary to use valves preventing suck-back of liquids into DUWL; the valves should be replaced at appropriate intervals [5].

4. A dental unit should be rinsed at the beginning of a working day, and between patients. The first type of rinsing assures elimination of microflora whose presence is due to the night stagnation. The second type, where 20-30 second rinsing is recommended, is to help reduce the risk of retraction of the oral cavity fluids, and aims at elimination of potential cross infection.

At the same time, it should be remembered that rinsing reduces bacteria concentration only temporarily, and exerts no influence on the biofilm. New bacterial contamination, which seems to be a result of bacteria release from the biofilm, was found at different times after rinsing [10, 30, 41].

5. Units with closed water systems should be used; they guarantee, with the application of disinfecting procedures, an adequate microbiological quality of water used for patient's treatment. Regular cleaning, disinfection and sterilization of the unit water reservoir, filling it with distilled water, and application of chemicals to monitor the microbiological quality of DUWL water, assures effective microbiological control of water and safety of the unit users [22].

Dental units with a system for heating water to human body temperature should not be used. The body temperature may favour development of microorganisms which are adapted to persist in the human organism, and may also be conductive to their growth in DUWL [2].

6. It is strictly recommended that a dental team should use personal protection measures (clothes, gloves, masks, protective goggles, visor shields).

Methods of aerosol and splatter control are simple and do not require high expenditure [3, 11, 14]. In the first place, emission of contaminated particles into the working space should be reduced, and next, contaminated particles should be eliminated from air before they have left the space directly surrounding the treated area.

Behaviour protecting a dentist and an assistant from the threat resulting from the influence of dental aerosol cannot be limited to isolated actions [13] and should include: 1. the use of personal protective measures; 2. rinsing the oral cavity of a patient with an antiseptic, e. g. chlorhexidine, before a procedure; 3. the use of high-performance sucking devices during aerosol production; 4. the use of devices reducing air contamination in a dental surgery.

The first 3 methods are simple and inexpensive, and should be applied routinely because they constitute the basic protection for a dental team.

Gloves, goggles, shields and masks belong to standard protective measures, are cheap, and universally used in dental surgeries as an effective barrier against splatter [3, 26]. This method is usually the only protective procedure against aerosol and splatter.

The other two methods of protection are also cheap, but are less frequently applied. Sucking devices are used where four-hand work with a patient in the supine position is possible.

The simulatneous use of a high-performance sucking device and cofferdam is recommended as an appropriate working method which protects a dental team against the influence of aerosol and splatter [7, 8, 29]. A high-performance sucking device, manoeuvred in the oral cavity and correctly positioned near a handpiece, is an effective method for aerosol reduction [40]. A sucking device, however, does not eliminate splatter effectively because large liquid particles, due to their high kinetic energy, escape from the range of the air stream flowing from a handpiece [26].

A ventilation and air-conditioning system in good working order, including air filters in air-condition devices, should be used to: 1. reduce contamination of a dental surgery environment, and 2. prevent circulation of microbiologically contaminated air. The latter method of prevention, however, involves technical changes and high expenditure.

One of the methods of air disinfection is irradiation with a lamp emitting ultra-violet radiation 250-265 nm (the so called UV-C). This light, and especially the light of 254 nm wavelength, shows a very high fungicidal, viricidal and bactericidal action through destruction of DNA chain and protein denaturation. UV lamps are obligatory dental surgery equipment, which follows from the sanitary and epidemiological regulations.

According to the author, insufficient awareness of health risk, working habits, and economic factors are the reasons why dentists do not apply the recommended methods of protection against the influence of bioaerosol and splatter.

The position of a patient during dental treatment is also significant. A patient should be treated in the supine position which, apart from other advantages, makes it possible for a doctor to avoid work in the breath way of a patient.

The necessity of immunisation of a dental team against biological hazards in their workplace through specific (vaccines) or non-specific (e.g. gamma globulin) immunisation of the organism seems obvious.

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