Evaluation of the risk of infection through exposure to aerosols and spatters in dentistry

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Background: Many dental procedures produce extensive aerosols and splatters that are routinely contaminated with microorganisms.

Methods: Air containing blood-bearing aerosols and surfaces contaminated by sedimenting blood particulate was sampled in 5 different dental cubicles. To assess contamination by blood particulate, the concentration of hemoglobin (Hb) in the air and on the sedimentation surfaces was determined.

Results: The mean concentration of Hb in the air aspirated in the 5 cubicles was $0.14 \pm 0.23 \mu g/m^3$, corresponding to a blood volume of $8.7 \times 10^{-4} \mu L/m^3$. Similarly, the mean concentration of blood particulate sedimented on surfaces was calculated and found to be $1.56 \mu L/m^2$. In 80% of the cubicles monitored, 100% positivity to the Hb determination test was recorded in all of the surface samples.

Conclusions: The results obtained revealed contamination of both air and surfaces by blood particulate. Moreover, with the exception of those obtained in 1 cubicle, all of the samples of sedimenting particulate analyzed were positive for the presence of Hb. (Am J Infect Control 2008;36:304-7.)

In dentistry, the risk of cross-infections among patients, or between patients and health care personnel, has been amply documented, especially with regard to bloodborne pathogens. The possibility of infection through blood-containing aerosols has been less thoroughly investigated, however.

Many dental instruments generate a cloud of particulate and fluid material during treatment sessions. In particular, aerosols containing biological material (saliva, blood, and dental plaque) and microorganisms are produced by high-velocity rotating instruments and air-water sprays or ultrasonic scalers. The particulates generated vary considerably in size. Once dispersed in the air, particles with a diameter > 100 \mu m soon precipitate, contaminating the surfaces on which they settle. Several pathogens are able to survive on surfaces for long periods, and these surfaces thus become reservoirs of infection. Some studies conducted in dental surgeries have found marked contamination of surfaces and instruments by bacteria and surface antigens of hepatitis B virus (HBV) and hepatitis C virus (HCV).

Most particles, however, are droplets < 100 \mu m in diameter. When the water evaporates, these give rise to so-called “droplet nuclei” composed of saliva, dried serum, and microorganisms. These droplets, the smallest of which (0.5 \mu m < \phi < 10 \mu m) can reach the pulmonary alveoli, can float in the air for several hours before settling and become a potential source of bacterial, viral, and fungal infection through inhalation and contact with the mucous membranes of the conjunctiva, nose, and oral cavity. Moreover, it has been hypothesized (although not yet proven) that bloodborne pathogens (eg, HIV, HBV, HCV) may be transmitted through the inhalation of blood-containing aerosols, because microlesions in the mucosa of the airways are potential access points for such viruses.

The present study was conducted to quantify the sedimenting blood particulate and blood components of aerosols produced during various dental procedures.

MATERIALS AND METHODS

Air containing blood-bearing aerosols and surfaces contaminated by sedimenting blood particulate were sampled in 5 cubicles, without a ventilation system, in different hospital dental clinics. The concentration of hemoglobin (Hb) present in the ambient air and on the sedimentation surfaces was determined. A 0.01 %
solution of Tween in distilled water was used to break down the erythrocyte membranes, thereby releasing the Hb into the medium. Hemastix strips were used to detect Hb in the collected samples. The detection limit of the test corresponds to a Hb concentration of 0.13 μg/mL in the extraction solution.

Sampling the airborne blood component

During 180 dental operations (eg, apicectomies, premolar and third molar extractions), the air sampling was done using a Zambelli ZB-CHRONO sampler (Zambelli, Bareggio/Milano, Italy) equipped with a cellulose nitrate membrane filter (Ø: 25 mm; porosity: 0.2 μm), positioned in proximity to the operating field by means of an extension tube between the patient and the operators (at about 20 cm from the operators’ surgical masks).

Because of the brevity of some of the procedures monitored, and to better concentrate the blood sample on the filter, thereby facilitating the subsequent measurement of Hb, aerosol samples from several consecutive operations were collected on the same filter. A total of 84 samples covered all of the operations performed.

At the end of the aspiration cycle, the filter was removed for Hb evaluation. For each day of sampling, the concentration of blood in aspirated air was calculated (μL blood/m³ air).

Sampling the sedimenting blood component

Simultaneously with the air sampling, surface samples also were obtained to evaluate the amount of larger sedimenting aerosolized particles of Hb. Surface sampling was carried out in duplicate by placing 16 cm² disposable collecting surfaces in a horizontal position close to the mobile tray. From the value of Hb concentration (μg/mL) yielded by the Hemastix test, the quantity of Hb (μg/m²) of surface area and of blood (μL/m²) was calculated.

A value of 0 was attributed to surface or air samples that tested negative (below the detection limit of the Hb concentration test). In negative controls evaluated when dental treatment was not in progress, the Hb concentration proved to be lower than the detection limit of the test used.

The data were processed using the intercooled Stata 8 statistical software (StataCorp, College Station, TX). Spearman’s correlation test was used to measure possible relationships between the concentration of Hb (in the air and on surfaces) and the working duration of the high-speed drill, as well as the concentration of Hb (in the air and on surfaces) and the total duration of sampling.

In addition, 53 dental health care workers who operated in shifts in the cubicles examined were interviewed with regard to anti-HBV vaccination. Our observations during monitoring sessions also allowed us to gather useful information on staff members’ behavior.

RESULTS

Airborne blood particulates

Considering the aggregate of all the samples, the mean concentration of Hb per cubic meter of aspirated air in the 5 cubicles examined was 0.14 ± 0.23 μg/m³. Table 1 gives the percentages of positivity to the test used to detect the presence of Hb in the air samples from each cubicle. The table also reports the mean concentration, median values, and the interquartile intervals of Hb in air.

Sedimenting blood particulate

With regard to the aggregate of all of the samples of sedimenting blood particulate, the sedimentation index Hb/m³ showed a mean value of 248.9 ± 321.9 μg/m³. Table 2 gives the percentages of positivity to the Hb detection test for the sampling surfaces in each of the cubicles examined, along with the mean and median values and interquartile intervals.

The degree of correlation among the variables airborne and surface concentration of Hb, working duration of the high-speed drill, and total duration of sampling was not significant (P > .05).

From the mean concentration of Hb in the air aspirated in the 5 cubicles (0.14 μg/m³), the mean volume of blood per cubic meter of air aspirated was calculated as 8.7 × 10⁻⁹ μL/m³. Similarly, the mean concentration of blood sedimenting on surfaces (1.56 μL/m²) was calculated as well.

The interviews conducted during sampling revealed that 15% of the dental health care workers interviewed had not yet been vaccinated against HBV, whereas 23.7% of those vaccinated stated that their vaccinations dated back to several years earlier, and that they had not undergone quantitative anti-HBs antibody assays to evaluate antibody cover.

Our observation of staff behavior during monitoring revealed that in the cubicles in which the surfaces were protected (by transparent film or napkins), these protections were never changed (except for the napkins on which surgical instruments were laid) between one patient and the next. Moreover, the handles of the lamp were wrapped in film, which was not changed between operations and on which traces of blood were visible. In those cubicles in which no surface protection was used, the surfaces, including the grip of the
high-speed drill, were never disinfected between one operation and the next.

DISCUSSION

In the present study, Hb was detected in the air and surface samples obtained during dental operations. This unequivocally indicates the presence of blood particulate both in aerosol form and sedimented on the surrounding surfaces. Moreover, with the exception of those obtained in cubicle 1, all the samples of sedimenting particulate analyzed were positive for the test for Hb (Table 2); in contrast, the air samples displayed variable positivity to the test, depending on to the cubicle considered (Table 1).

Because sampling of the 2 particulate fractions was carried out in parallel, this finding reveals that some dental instruments (the high-speed drill was the most frequently used instrument during our sampling) produce a heavier blood particulate, which tends to settle quickly. Although rare, transmission through contact with droplet-contaminated surfaces or instruments has been shown to be possible.9

Our observation of the behavior of dental staff members revealed evident shortcomings in terms of the risk of infection from contaminated surfaces. Indeed, the Centers for Disease Control and Prevention (CDC) has underlined the importance of thoroughly sanitizing surfaces, not only at the end of the working day, but also between operations.10 Microorganisms from contaminated surfaces are transferred to patients or personnel primarily through hand contact. When these surfaces are touched, microbial agents can be transferred to instruments, other environmental surfaces, and the nose, mouth, or eyes of staff or patients. Moreover, in the presence of lesions of the skin or mucosa, microorganisms, including bloodborne ones, may enter into the host.

With regard to the airborne blood component, whether infection by blood-borne viral pathogens can occur through the inhalation of contaminated aerosolised blood particulate remains uncertain. Although this possibility has been hypothesized,1,8 how long such microorganisms can survive in aerosols, how infective they are in this medium, and how effectively they can penetrate through an unconventional route have not yet been determined. Nevertheless, alongside the recognized percutaneous and mucocutaneous transmission modalities of these pathogens, the possibility of infection through the inhalation of blood-containing aerosols, although not yet demonstrated, cannot be ruled out.

In the light of these considerations, it is clear that dental health care workers need to adopt a policy of prevention; combining the various preventive measures available can effectively reduce microbial

Table 1. Number of samples taken, number of dental procedures monitored, volume of air aspirated (liters), percentage of positivity to the Hb determination test, range, mean value, median, and interquartile interval (Q1–Q3), with regard to the concentration (μg/m³ aspirated air) of airborne hemoglobin in the 5 dental cubicles examined

<table>
<thead>
<tr>
<th>Cubicle</th>
<th>Number of samples</th>
<th>Number of dental procedures</th>
<th>Mean volume of air aspirated</th>
<th>% positivity to test</th>
<th>Range</th>
<th>Mean value</th>
<th>Median</th>
<th>Q1–Q3</th>
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<td>0</td>
<td>0</td>
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<td>0*</td>
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<td>2</td>
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<td>33</td>
<td>170.2</td>
<td>33.3</td>
<td>0</td>
<td>0* to 0.72</td>
<td>0.16 ± 0.29</td>
<td>0</td>
</tr>
<tr>
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<td>0.15 ± 0.26</td>
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<td>93</td>
<td>196.5</td>
<td>41.7</td>
<td>0</td>
<td>0* to 0.7</td>
<td>0.15 ± 0.23</td>
<td>0*</td>
</tr>
</tbody>
</table>

*Note: A value of 0 was attributed to samples testing negative for Hb (below the detection limit of the test).

Table 2. Number of samples taken, percentage of positivity to the Hb determination test, range, mean value, median, and interquartile interval (Q1–Q3), with regard to the concentration (μg/m²) of hemoglobin on surfaces in the 5 dental cubicles examined

<table>
<thead>
<tr>
<th>Cubicle</th>
<th>Number of samples</th>
<th>% positivity to test</th>
<th>Range</th>
<th>Mean value</th>
<th>Median</th>
<th>Q1–Q3</th>
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<tbody>
<tr>
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<td>0</td>
<td>0*</td>
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<td>90 to 240</td>
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<tr>
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<td>120 ± 90</td>
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<tr>
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<td>170 ± 70</td>
<td>150</td>
<td>110 to 200</td>
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</tbody>
</table>

*Note: A value of 0 was attributed to samples testing negative for Hb (below the detection limit of the test).
contamination and the risk of occupational infection and cross-contamination. This approach is strongly supported by organizations such as the CDC, the American Dental Association, schools of dentistry, and other associations.

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References