IS ORDINARY ELECTRIC DRILLS' VENTING PORT A POTENTIAL SOURCE OF SURGICAL INFECTION?

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ABSTRACT

Objective: To evaluate the potential risk of surgical contamination by the venting port of ordinary electric drills (ED) employed in orthopaedic surgeries. Materials and Methods: an experimental laboratory, randomized study was developed to analyze EDs in surgical practice and new cleaned and sterilized equipment, which were contaminated with Bacillus atrophaeus spores at a concentration of 84 X 10_6 UFC. The air generated by the engine of each drill was collected and cultivated on sterile agar plates. Results: Positive culture was identified in two ED in surgical practice, as well as a positive culture to Bacillus atrophaeus with 1 CFU growth (1,19 X 10_{-8}). Conclusion: In the conditions of the experiment, the air generated by the venting port of the ED´s engine does not consist of a source of contamination for the surgical site.

Keywords: *Orthopaedic surgery. Contamination. Orthopaedic equipment. Surgical wound infection. Prosthesis-related infection. Air microbiology.*

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INTRODUCTION

The increasing technological development in surgery has provided a higher number of interventions with lower risk; however, infections associated to healthcare constitute a strong concern for healthcare professionals. Surgical site infection in University Hospitals has been shown to be the most frequent one among patients submitted to surgeries, ranging from 11 to 16%.[1,2]

In a specialized university hospital, the incidence of infection in hip total arthroplasties was 13%[3], while in knee total arthroplasties, this has been around 3%.[4,5] The occurrence of infection in a patient submitted to orthopaedic surgery is regarded as a serious event, with osteomyelitis being the most serious complication, which can persist ultimately leading to functional deficiency of ends.[6]

Orthopaedic surgeries require the use of equipment for bone perforation. Specific drills for medical-surgical use, in general, enable appropriate cleaning procedures in order to assure the sterilization process; however, Brazilian hospitals make use of ordinary domestic electric drills in orthopaedic surgeries. Such equipment has venting ports, through which contamination may occur as a result of blood spills and debris. Considering that the cleaning procedure after surgical use is performed just on the external parts because of the impossibility of soaking the equipment into a detergent solution, the organic material will probably remain on internal parts, which may trouble the sterilization process. Therefore, when an electric drill (ED) is activated on the operating room, there will be risk of contaminated aerosols being produced, thus leading to contamination of the surgical field.[7]

National publications on surgical site infections in orthopaedic surgeries do not identify the use of ordinary domestic ED as a risk factor, although professionals are usually concerned with improper and improvised use.[3-5] In an American study, the air vent from pneumatic drills, specifically designed for surgical use, was evaluated for the presence of bacteria and the ability to contaminate surgical fields.[8] Whereas there are no investigations assessing EDs employed in orthopaedic surgeries and the possibility of contamination of the surgical field by the production of aerosols when the engine is activated, this study was developed to provide a microbiological assessment of the vent produced when the engine of an ED used in orthopaedic surgeries is activated.

MATERIALS AND METHODS

This was an experimental, laboratory-based, randomized applied research designed to assess the air vent produced by the activation of an ED engine. One by one, the machines were turned on for 3-6 minutes and the air produced by engine venting was oriented to Petri plates with a solid culture medium made of soy casein (TSA, Difco™, BD), positioned at a distance of 5 cm inside a laminar flow chapel (VLFS 12, VECO®, Campinas – SP) as shown on Figure 1. This study was developed in two phases at the laboratory of experimental research of the Medical-Surgical Nursing Department, University of São Paulo Nursing School (EE-USP).

All the authors state no potential conflict of interest concerning this article.

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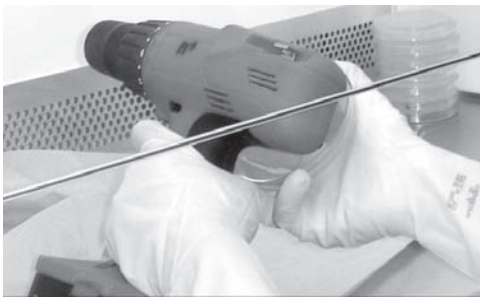

Figure 1 – *Air collected for culture*

2.1. Phase I

Air samples were collected from 15 EDs following orthopaedic surgical use at the Institute of Orthopaedics and Traumatology of Hospital das Clínicas (IOT-HC), Medical School, University of São Paulo (FMUSP) between 03/05 and 04/09/2007. The distribution was randomized and blinded. The researcher collected two available EDs at the moment of visit with the area nurse. All surgeons-doctors and operating room/ warehouse staff were blinded to the research. Of 15 EDs assessed, three came directly from the operating room, three from the cleaning area of the warehouse, and nine after sterilization, three of them with hydrogen peroxide plasma (HPP) at IOT-HC; three with ethylene oxide (ETO) at HC Sterilization Center, and three with low-temperature steam and formaldehyde (LTSF) in an independent Sterilization Center.

2.2. Phase II

Air samples were collected from 22 new EDs between 07/30 and 08/20/2007. Of the 22 EDs, six were used as positive control and 16 constituted the experiment. Three medical-surgical bone drills Dyonics® 450 Drill, Smith Nephew (Andover, MA. USA) were included s negative control. All new equipment were previously cleaned and sterilized with ETO. Randomization was made to process BD or ED, and, when ED, if experiment or positive control. The machines were submitted to intentional contamination (Figure 2) with 30 mL of a solution containing defibrinated and sterilized lamb blood and *Bacillus atrophaeus* spores (American Type Culture Collection - ATCC 9372™), 2,8 x 10^6 spores/mL, in a laminar flow chapel for approximately 60 minutes, which is the average time for an orthopaedic surgery. The 16 EDs of the experiment and the three BDs of the negative control were submitted to cleaning and sterilization process with ETO, then the air samples could be collected. The 6 positive-control EDs had the samples collected after the contaminant exposure time.

Properly identified agar plates were incubated in a heater for culture (Orion®, Model 502, Fanem São Paulo – SP), for 72 hours at a temperature of 37 ^{o}C, and this time was extended for 14 days, with daily readings. For the plates presenting growth, colonies and Gram were counted. For positive cultures of intentionally-contaminated equipment (phase II), Gram and Wirtz-Conklin staining was performed in order to visualize spores, as shown by Figure 3. The analysis of the phase I results was made by the cell counts, and the analysis of the phase II results was made by applying a microorganism survival probability formula, considering the known initial load.

Survival probability

$$\text{Survival rate} = \frac{Nt}{N_0}$$

N_0 = baseline concentration = number of live cells at baseline = 2.8 x 10^6 UFC/mL x 30 mL = 84 x 10^6 UFC

Nt = resultant concentration = number of live cells at processes completion

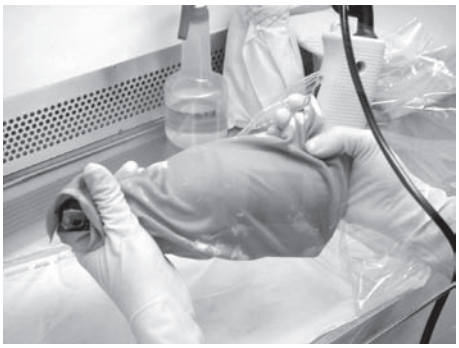

Figure 2 – *Intentional contamination of the electric drill*

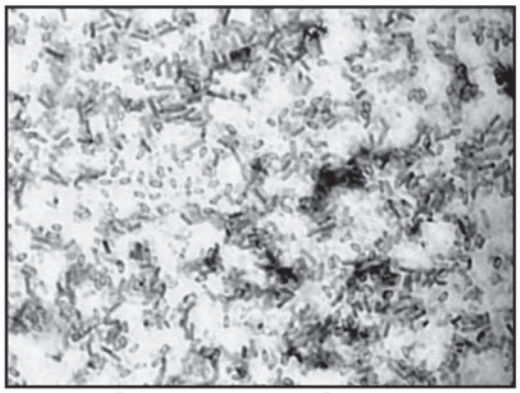

Figure 3 – *Wirtz-Conklin staining, with several spores (white) being visualized under microscope originated from the air vented from a positive-control electric drill*

2.3. Sample size

This has been calculated by taking into account for a successful effect an efficiency of 99.9% of the ethylene oxide sterilization and, for a failed effect, 50%. The sample size on phase II, experimental, was estimated as 16 units excluding the 6 positive-control units and the 3 negative-control bone drills specifically designed for surgical use.

Figure 4 shows a schematic illustration of the methodology developed for this study.

RESULTS

3.1. Phase I

Of the 15 EDs included in surgical practice, two units did not work at the moment of collection; therefore, 13 were assessed by microbiological culture of the air produced by turning on the engine. The results are presented on Table 1; two units showed growth of 1 Gram-positive coccus colony-forming unit (CFU) by plate.

3.2. Phase II

The air produced by turning the positive-control EDs engine on was collected after elapsed the time of intentional contamination exposure with *Bacillus atrophaeus*, with all of them presenting bacillus growth after 24-h incubation at 37 ^{o}C, as presented on Table 2. After 3-4 days of incubation, the Wirtz-Conklin staining confirmed the presence of spores. The results of air samples collected from experiment EDs and negative-control BDs are presented on Tables 3 and 4, respectively. Of the 16 studied EDs, seven presented with growth, from 1 to 2 CFU. Of these, four showed bacillus colonies, but only in one the presence of spores was confirmed. All confirmation procedures were conducted. *Bacillus atrophaeus* retrieval

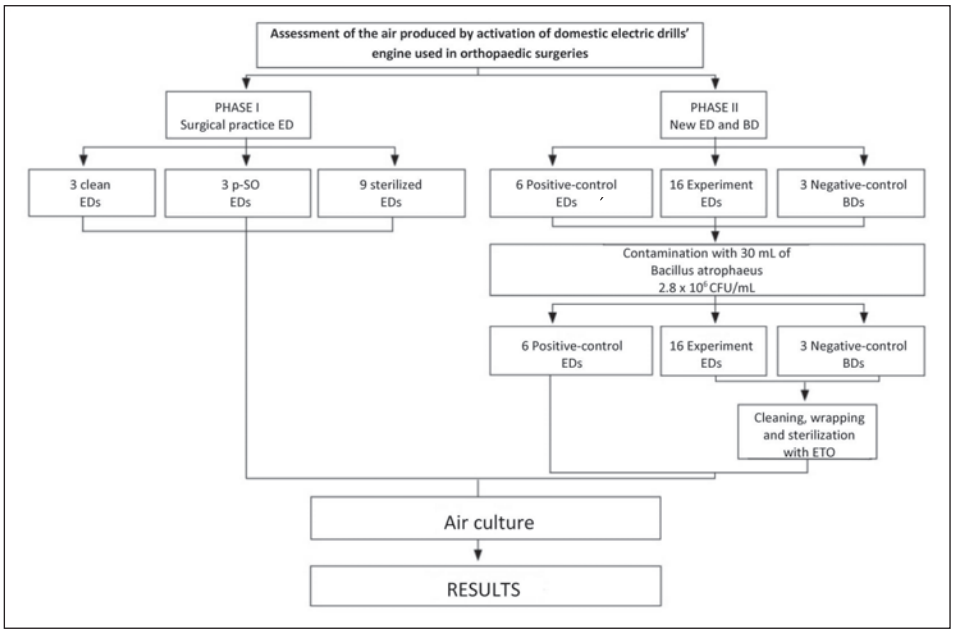

Figure 4 – *Methodology developed for the study.*

Table 1 – *Results of microbiological cultures of the air produced by activating the engine of electric drills used in surgical practice according to tests sequence. São Paulo, 2007*

Identification	Status	Result	
ED1	Sterilized with HPP*	Negative	
ED2	Sterilized with HPP*	Negative	
ED3	Sterilized with HPP*	Negative	
ED4	Clean	Negative	
ED5	After surgery	Negative	
ED6	After surgery	Positive: 1 CFU	Gram-positive coccus
ED7	Sterilized with ETO**	Negative	
ED8	Sterilized with ETO**	Negative	
ED9	After surgery	Negative	
ED10	Clean	Negative	
ED11	Sterilized with LTSF***	Negative	
ED12	Sterilized with LTSF***	Positive: 1 CFU	Gram-positive coccus
ED13	Sterilized with LTSF***	NC****	
ED14	Clean	NC****	
ED15	Sterilized with ETO**	Negative	

***HPP: hydrogen peroxide plasma; **ETO: ethylene oxide; ***LTSF: low-temperature steam and formaldehyde; ****NC: not collected – sample not collected due to ED malfunction.**

Table 2 – *Results of microbiological cultures of the air samples collected from positive-control (PC) electric drills (ED) according to the chronological sequence of the experiments. São Paulo, 2007*

Identification	Results	
	Positive / Negative	CFU count
ED1.PC	Positive	20 CFU/plate
ED5.PC	Positive	50 CFU/plate
ED6.PC	Positive	5 CFU/plate
ED8.PC	Positive	Uncountable
ED13.PC	Positive	500 CFU/plate
ED14.PC	Positive	Uncountable

was confirmed for one ED, although only 1 CFU, meaning a microorganism survival rate of 1.19×10^{-8}. As no other plates showed growth, we can state that the microorganism survival probability and airborne dissemination on the other EDs was $< 1.19 \times 10^{-8}$.

DISCUSSION

A high risk of internal contamination by blood spills and debris was attributed to EDs due to the impossibility of performing a proper cleaning procedure, for this is an electric machine, which cannot be soaked into a detergent solution. The importance of

Table 3 - *Results of microbiological cultures of the air samples collected electric drills (ED) according to the chronological sequence of the experiments. São Paulo, 2007*

Identification	RESULTS					
	Positive/Negative	CFU/plate	Gram (G) staining	Wirtz-Conklin staining		
				1st	2nd *	3rd **
ED2	Positive (10th day)	1 CFU	G Positive Coccus	---	---	---
ED3	Negative	---	---	---	---	---
ED4	Positive (2nd day)	1 CFU	G Positive Coccus	---	---	---
ED7	Positive (2nd day)	2 CFU	G Positive Coccus	---	---	---
ED9	Negative	---	---	---	---	---
ED10	Negative	---	---	---	---	---
ED11	Positive (1st day)	1 CFU	G Positive Bacillus	Negative	Negative	Negative
ED12	Negative	---	---	---	---	---
ED15	Negative	---	---	---	---	---
ED16	Negative	---	---	---	---	---
ED17	Negative	---	---	---	---	---
ED18	Positive (1st day)	1 CFU	G Positive Bacillus	Questionable***	Positive	Positive
ED19.GE	Negative	---	---	---	---	---
ED20.GE	Positive (5th day)	1 CFU	G Positive Bacillus	Negative	Negative	Negative
ED21.GE	Positive (3rd day)	1 CFU	G Positive Bacillus	Negative	Negative	Negative
ED22.GE	Negative	---	---	---	---	---

*** 2nd Wirtz-Conklin staining was carried out after the re-striking.; ** 3rd Wirtz-Conklin staining was carried out after thermal shock; ***Questionable: bacterial spores visualization was unclear.**

Table 4 - *Results of microbiological cultures of the air samples collected from negative-control (NC) bone drills (BD). São Paulo, 2007*

Identification	RESULTS					
	Positive/Negative	CFU/plate	Gram (G) staining	Wirtz-Conklin staining		
				1st	2nd *	3rd **
BD1.NC	Negative	---	---	---	---	---
BD2.NC	Negative	---	---	---	---	---
BD3.NC	Negative	---	---	---	---	---

*** 2nd Wirtz-Conklin staining was carried out after the re-striking.; ** 3rd Wirtz-Conklin staining was carried out after thermal shock.**

cleaning medical-surgical materials to assure the efficiency of sterilization processes is well-known. Researchers have proven the low microbial load in surgical materials after its use, both before and after cleaning, in average, 10^2 CFU/material.[9-11] The results of culture analysis of the air produced by ED engines during the phase I of this study showed that the air vent has a poor ability to move microorganisms from inside an ED used in surgical practice to the environment, i.e., to the surgical field. The same concern with surgical field contamination has called American researchers'interest[8] investigating pneumatic BDs, with the reservation that these consist of equipment specifically designed for bone perforation in orthopaedic surgeries using pressurized air to activate the engine. The results of the investigation by Sagi et al.[8] suggest that the air flow produced during venting causes air swirling that moves particles from non-sterile surfaces to the surgical field. The low positivity of cultures in the present study, comparing to the results of the American study[8] can be justified both for the collection made in the laminar flow chapel under aseptic and controlled conditions and for engine's low venting ability to move particles or microorganisms from inside and ED to the outer environment. Sagi et al.[8] tested different engine activation times and different distances between the equipment and Petri plates, respectively, 15-30 seconds and 10-30 cm. In that investigation, a longer exposure time was employed: six minutes on phase I and three minutes on phase II, and a shorter distance (5 cm) between the equipment and the plate at the moment of collection. Sagi et al.[8] found 21 and 25 CFU in each BD tested. The sample in the present investigation was bigger, and only 1 CFU/ED was found in two EDs on phase I and, when the inoculated microorganism was investigated on phase II, 1 CFU was identified in only one ED.

The results of this experiment showed that the microbial survival rate inside an ED is very low, while the probability of microorganism dissemination during the duty cycle of an ED was 1.19×10^{-8}. Surgical site infection is known to potentially occur due to a microbial contamination at the surgery environment, depending on factors such as amount of inoculated microorganisms, its virulence, and patient's immunologic status. The risk of infection is enhanced when the site is contaminated by microorganisms at a concentration above 10^5 by gram of tissue, although the required inoculums to cause infection can be much lower when accompanied by some other material, such as, for example, 10^2 microorganisms introduced through suture wiring.[12] This study is not intended to recommend or approve the use of domestic EDs in surgeries, because the contamination potential by the air produced by engine venting ports is absent. Investigating the equipment for its mechanical control, the efficiency of sterilization with ETO, tissue damage, and the occurrence of bone necrosis, among other important aspects, is required. Thus, we could contribute to the development of a more ethical and safe healthcare practice.

CONCLUSION

The results of this investigation allow us to conclude that, under the conditions of the study, although the air produced by electric drill engine's venting port has moved 1.19×10^{-8} contaminants to the surrounding environment, that amount is not enough to characterize risk of infection at a surgical site.

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