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SHORT COMMUNICATION

BACTERIAL POLLUTION OF CUTTING FLUIDS: A RISK FACTOR FOR OCCUPATIONAL DISEASES

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An outbreak of occupational diseases involving 38 metal workers with local infections on the hands and the face (53%), bronchitis (29%), and bronchopneumonia (18%) urged an examination of 150 samples of emulsions which the workers used in processing metals. Among the isolated bacteria, the most frequent was *Pseudomonas aeruginosa* (48%), followed by *Escherichia coli* (44%), *Proteus* spp. (11%), *Enterococcus faecalis* (9%), *Enterobacter aerogenes* (7%), *Citrobacter* spp. (5%), *Shigella* spp., *Staphylococcus aureus* (3%), and the sulphite reducing *Clostridia* (1%). Moulds and yeasts were isolated from all tested samples. Most samples counted about $3x10^5$/ml of colony forming units. It was concluded that all emulsions and other substances which come in direct contact with the workers should be regularly monitored. Furthermore, preservatives should be added to prevent microbial infection.

Key words:
aerogenous infections, metal workers, microbial agents, occupational exposure, *Pseudomonas aeruginosa*

Airborne occupational diseases (aerogenous infections) have become increasingly important in all industrial branches, particularly in metal processing (1). These diseases are generally defined as a complex of various respiratory system disorders caused by inhalation of noxious components of substances either directly or indirectly used in a manufacturing process or, to a certain extent, associated with the process. Workers and other employees who are not in direct contact with fluids used in processing metals are exposed to those lubricants, the components of which are dispersed all over the workplace in the form of gas, smoke, or oil mist.

Contradictory opinions are found in literature on the effects of oil mists on the workers' respiratory tract. A study undertaken in the USA has shown a higher incidence of respiratory system diseases, including chronic cough, increased secretion, functional disorders, pharyngitis, laryngitis, sinusitis, and rhinitis in the exposed than

nonexposed workers (1). Aqueous oil emulsions used in metal processing are not sterile. Contamination may occur whenever these come in contact with people and various objects involved in the process. The use of non-potable water in preparation of such emulsions only increases the risk of bacterial contamination. Some of these systems are readily colonised by Gram-negative bacteria. *Tant and Bennett* (2, 3) observed that Gram-positive microorganisms were extremely sensitive to and therefore unable to survive in oil emulsions, while Gram-negative pathogens survived in emulsions over a period of up to 250 days. An opposite view comes from *Chazal* (4) whose recent investigations conducted in France have shown that it was not possible to isolate Gram-negative microorganisms or Gram-positive cocci from certain emulsions, probably due to the addition of efficient biocides.

The emulsion being an appropriate medium for bacterial growth, several contaminants not only survive but, as a rule, show very fast proliferation (5). Microorganisms use nutrients containing carbon, hydrogen, nitrogen, sulphur, traces of phosphorus, magnesium, calcium, and many other components normally found in emulsions used in the metal processing industry (6). The presence of water and oxygen favours the growth of aerobic bacteria. Average emulsion temperatures of 40 °C create optimal conditions for the growth of bacteria, yeasts, and moulds (7). Aerobic microorganisms consume oxygen and in the process of oil separation help create ideal conditions for the growth of anaerobic microorganisms. A decrease in pH as a result of microbial dissimilation and decomposition of corrosion inhibitors lead to increased corrosive activity of cutting fluids. Lactose fermenting and anaerobic sulphite-reducing bacteria cause off-odours in the contaminated emulsion (8). Considerable numbers of microorganisms are encountered in the vicinity of machines. Microclimatic contamination is associated with formation of aerosols. Many microorganisms produce toxins which directly affect workers through aerosols. From the point of view of occupational medicine, 10^6–10^7/ml of microorganisms constitute a high risk for all workers involved in metal processing. In 1978, the UK Health and Safety Agency adopted a regulation specifying that conditions detrimental to human health are considered to arise when colony forming units of bacteria exceed 10^4/ml, depending on the type of bacteria and individual susceptibility of workers (9).

Relevant factors are primarily workers' anamneses, working and environmental conditions, exposure time, and disappearance of symptoms after a longer absence from work. This particularly refers to the so called irritative dermatitis which is most frequently manifested as red, dry skin on the palms and fingers, scales, and excessive pigmentation (10). Such degreased, exposed, and irritated skin is particularly susceptible to bacterial infections by *Pseudomonas aeruginosa*, *Proteus* spp., *Streptococcus* spp., or other bacteria (11–15).

Čapeta and co-workers (10) point out that respiratory diseases in metal workers which come in contact with cooling emulsions should be considered in relation to certain factors such as microbial contamination of emulsions, toxicity of metals, mechanical damage of the mucous membrane of the respiratory system (vapours, »metallic dust«), and allergic reactions to bacteria and fungi.

The bacteria most frequently colonising emulsions are those of the genus *Pseudomonas* and *Enterobacteria*, as well as moulds and yeasts. *Pseudomonas aeruginosa* may cause festering wounds on damaged skin and intestinal infections of dysenteric nature (16). The above mentioned microorganisms are widely spread in soil, sewage,

and in the air. They grow very rapidly in any aqueous medium, but their growth is also possible in such unfavourable environment as soap, detergent, and antiseptic solutions. In addition to the skin, bacterial colonies may develop in the upper respiratory tract and cause pneumonia (3). *Tant and Bennett* further report that *Escherichia coli* originating in the human intestinal tract has also been isolated from emulsions. Likewise, *Proteus* bacteria are ubiquitous in water, various aqueous solutions, and in the intestine. Their presence in other parts of the human body may lead to infections of the skin and of the urinary tract and may cause pneumonia and sepsis. They grow fast in alkaline environments. *Klebsiella* spp., particularly *K. pneumoniae,* is generally recognised as pathogenic for the respiratory system, causing pneumonia, tonsillitis, and the inflammation of the middle ear. Recently, it has often been isolated from contaminated substances used in metalworking. It may originate from the saliva of persons in the subclinical phase of a disease. Combined infections such as cystitis and pyelitis are rather frequent. *Klebsiella* spp. may cause diarrhoea, particularly in very young children. *Salmonella* spp. is a typical example of pathogenic bacteria and is frequently found in emulsions. There are some indications that these microorganisms may survive in emulsions for as long as 33 days or over (3). *Staphylococcus aureus* usually survives in emulsions from 24 to 48 hours (2). Other microorganisms found in emulsions are those of the genera *Micrococcus*, *Citrobacter*, *Acinetobacter* and *Bacillus*, as well as *Clostridium perfringens*, *Providencia* and *Enterococcus faecalis*. The fungus *Candida*, which may cause mycoses and affect the skin and the mucous membrane, is also mentioned in the literature as a frequently found emulsion contaminant (2).

The aim of this study was to identify the presence of microbial agents in cutting fluids to which workers are continuously exposed.

SUBJECTS, MATERIAL, AND METHODS

An increased number of workers with health problems was observed in a metal processing plant producing automobile parts. All the examined workers had been heavily exposed to cutting fluids.

A total of 150 emulsion samples of approximately 100 ml each were collected from metal processing equipment directly involved in the technological process and transferred to sterile plastic bottles which are used as engine oil containers. Each one-millilitre aliquot emulsion sample was cultured in a 4% selenite broth, salt broth, brilliant green broth, tryptose broth, in sulphite agar for clostridia, and in a 4% Sabouraud Maltose Agar for moulds and yeasts. After incubation at 37 °C for 18 hours the material was transferred from the selenite broth to SS-agar to differentiate *Salmonella* spp., *Shigella* spp., *Enterobacter aerogenes*, and *Proteus* spp. Salt broth and tryptose broth were incubated at 37 °C for 48 hours and a loopful thereof was transferred to Baird-Parker agar for *Staphylococcus aureus*, to Kanamycin Esculin Azide agar for *Enterococcus faecalis* and to King-agar B for *Pseudomonas aeruginosa*. Brilliant green broth was incubated at 42 °C for 48 hours and then the material was plated on Endo-agar to differentiate *E. coli*, *Citrobacter* spp., and *Klebsiella* spp. Dehydrated culture media of »Merck«, (Darmstadt, Germany) were used throughout the procedure.

RESULTS AND DISCUSSION

The first outbreaks of adverse effects on workers were observed in spring and summer 1992. Thirty-eight workers required medical care, 20 of whom were diagnosed skin infections of the hands and face, whereas 18 were diagnosed bronchitis and bronchopneumonia. *Pseudomonas aeruginosa* was isolated from the sputum and hand lesions of all affected workers and identified as the principal cause of diseases.

The clinical findings prompted bacteriological investigations of cutting fluids in the summer 1992. From the 150 tested emulsions, *Pseudomonas aeruginosa* was most frequently isolated. Figure 1 shows the number of positive findings of isolated microorganisms. The above results show that *Pseudomonas aeruginosa* was isolated in 72 samples (48%), followed by *E. coli* in 66 samples (44%), *Proteus* spp. in 17 samples (11%), *Enterococcus faecalis* in 13 samples (9%), *Enterobacter* spp. in 11 samples (7%), *Citrobacter* spp. in 8 samples (5%), *Shigella* spp. and *Staphylococcus aureus* in 5 samples (3%), and sulphite-reducing clostridia in 2 samples (1%). Moulds and yeasts were isolated from all tested samples. The total bacterial colony count in the tested emulsion samples was relatively high; in most samples it amounted up to $3x10^5$/ml.

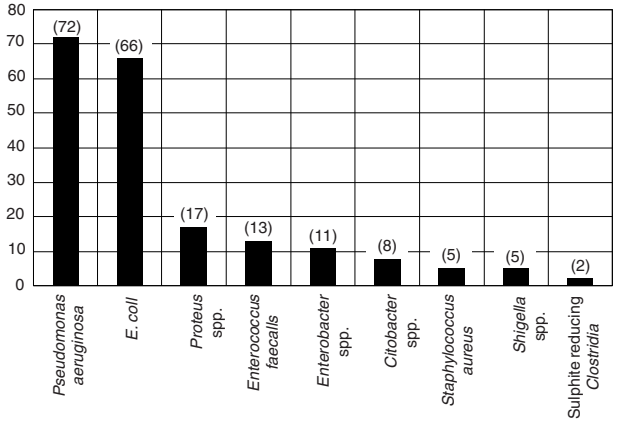

Figure 1 *Positive findings in emulsions tested for microorganisms*

Our results and the literature data indicate that emulsions used in metal processing are highly contaminated with various pathogenic and potentially pathogenic bacteria and fungi which may be associated with respiratory and other infections in exposed workers. This is particularly true for the high level of contamination with *P. aeruginosa* (48%).

Beside their irritant properties, substances used in metal processing often contain moulds, yeasts, and various bacteria which cause respiratory infections that may become chronic diseases. Such diseases reduce the body's ability to resist other infections, including relapses or prolonged duration of the primary disease, resulting in irreversible tissue decay. The most frequent respiratory system diseases are bronchitis, pneumonia, and emphysema.

It is obvious that most microorganisms causing the contamination of emulsions are normally present in the human body. This confirms the assumption that the environment and the unwashed hands of workers are the primary sources emulsion contamination in the metal processing industry. Another most likely source is non-potable water with a very high content of microorganisms ($3x10^4$/ml) (16).

Our investigations corroborate findings of other authors on the causal agents of the above mentioned disorders. Considering the health risks, all emulsions and other substances which come in direct or indirect contact with workers should be subject to strict monitoring on a regular basis and should be added preservatives, as do recommend suppliers of such additives to cutting fluids. The recognition of these incidents is not widespread, and more attention should be paid to their prevention.

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Sažetak

BAKTERIJSKO ONEČIŠĆENJE EMULZIJA ZA OBRADU METALA – RIZIČNI ČIMBENIK PROFESIONALNIH BOLESTI

Epidemija u 38 metalaca s lokalnim infekcijama kože ruku i lica (53%), bronhitisa (29%) i bronhopneumonije (18%) mahom uzrokovanih bakterijom *Pseudomonas aeruginosa*, potaknula je ispitivanje 150 uzoraka uljnih emulzija za obradu metala. Najčešće izolirani mikroorganizam bio je *Pseudomonas aeruginosa* (48%), a slijedili su *Escherichia coli* (44%), *Proteus* spp. (11%), *Enterococcus faecalis* (9%), *Enterobacter aerogenes* (7%), *Citrobacter* spp. (5%), *Shigella* spp., *Staphylococcus aureus* (3%) i sulfito reducirajući klostridiji (1%). Kvasci i plijesni izolirani su iz svih pretraženih uzoraka. Broj živih bakterija u većini uzoraka iznosio je do $3x10^5$/ml. Zaključeno je da bi sve emulzije i druge tvari s kojima metalci dolaze u izravan ili neizravan dodir trebalo redovito nadzirati. Nadalje, trebalo bi stavljati dodatke za konzerviranje maziva da se spriječe mikrobijalne infekcije radnika.

Ključne riječi:
aerobne infekcije, metalci, profesionalna izloženost, *Pseudomonas aeruginosa*

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