**Microbiological contamination of radiological equipment.**

(Article begins on next page)

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# UNIVERSITÀ DEGLI STUDI DI TORINO

**Title: Microbiological contamination of radiological equipment**

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**Abstract**

**Background:** Important changes have occurred in radiological departments over the past 30 years. The procedures have become more complex and the number of patients has increased. This scenario could have important implications for public health and infection control but, to date, the scientific literature has dealt little with matters relating to microbiological monitoring in radiological departments.

**Purpose:** To examine the level of microbiological contamination in the main radiological departments of Turin, a city in northern Italy, in order to analyze the presence of a possible biological risk.

**Material and Methods:** We analyzed data from 12 RD. Samples were taken from X-ray tubes, control panels, radiographic cassettes and imaging plates. We used the French guidelines "Standards NF S 90-351" in order to obtain the threshold values of reference. Through a questionnaire we investigated the use of Personal Protective Equipment by the chiefs of the radiological departments.

**Results:** We found values out of limits in 41.7% of the X-ray tubes sampled, in 91.7% of the control panels and imaging plates, while only the 8% of radiographic cassettes were contaminated. The 58.3% of radiological departments reported values above the threshold for three out of four samples. In 16.7% of the radiological departments only one surface presented acceptable values.

**Conclusion:** Healthcare-associated infections are a cogent issue for the radiological departments, and the knowledge about how to prevent them is increasingly required by health professionals. This study meant to be a first analysis of the issue that highlights the need of further investigations, maybe with a more detailed monitoring through the characterization of the microbial species involved. Moreover, the development of shared and maybe official standards for the evaluation of microbiological contamination in radiological departments is strongly suggested.

**Introduction**

The radiological services reach a broad range of patients, including hospitalized patients, outpatients, intensive care or emergency patients, immunocompromised and chemotherapy-treated patients, and patients with tuberculosis or other infectious diseases (1,2). In spite of the different characteristics of the patients, the examinations are performed often with the same equipment and within the same environment. In this context, the surfaces of equipment could represent a reservoir for pathological agents and source of transmission of infections to patients and healthcare professionals (3). In the radiological departments, similarly to other hospital departments, it is recommended the adhesion to international standards and guidelines of hygienic procedures (4). For example, the CDC guidelines report that "cleaning and disinfection of all patient care areas is especially important for frequently touched surfaces, such as bedrails, bedside tables, commodes, doorknobs, sinks, and equipment in proximity to the patient"(5). Interestingly, the scientific literature reports some experiences regarding the investigation and the control of potential risks related to the methicillin-resistant Staphylococcus aureus (MRSA) contamination within a radiological department (6-9). Other studies were conducted in China and Taiwan during the severe acute respiratory syndrome (SARS) epidemic (10-13). The Disease Control Bureau of these countries identified the radiological department as a setting with high-level risk of infection. As far as concerns the radiological settings, several articles investigated the risk focusing on mobile x-ray imaging techniques. For instance, Aso et al. found highest levels of contamination on CR consoles and HIS/RIS terminals and suggested this was attributable to wrong procedures in cleaning and disinfection (14). Levin et al. reported a poor practice of infections control measures among radiography technicians and demonstrated that the radiograph equipment is frequently colonized by highly resistant bacteria (15). To date, in Italy, studies aiming at monitoring bacterial contamination in radiological departments have never been conducted. Moreover, the Italian legislation is very poor regarding the regulation of environmental microbiological monitoring in healthcare setting. Finally, the National Plan Guidelines (PNLG) does not establish any maximum limit.

The present study aims to examine the level of microbiological contamination in the main radiological departments of nine hospitals in Turin, a large city in northern Italy, in order to analyze the presence of a possible biological risk, both for users and for health professionals, and also to enhance the attention on the habits of good hygienic practices by the personnel of these structures.

**Material and Methods**

The observational study included data from 12 radiological departments belonging to nine hospitals of the urban area of Turin, Italy. The study consisted of two contemporary phases: we carried out a microbiological monitoring of the radiological surfaces and we administered a questionnaire about prevention of biological risks in the same structures.

*Microbiological monitoring*

The study evaluated the presence of bacteria on the surfaces examined. In order to standardize monitoring techniques a specific sampling campaign has been set, following the 2010 "CONTARP guidelines" (16). CONTARP is a working group composed by technical advisors, with expertise in occupational risk assessment and prevention, collaborating with the Italian Workers Compensation Authority (INAIL). The CONTARP guidelines have been developed with the specific aim of elaborating and standardizing the procedures of microbiological sampling in the occupational field. Areas and size of surfaces for our sampling were standardized and selected taking into account these guidelines and the frequency of use during radiological activities. The following surfaces were included:

- X-ray tube: 100 cm2;

- Control panel: 100 cm2;

- Imaging plate: 400 cm2;

- Radiographic cassette and Image detection system - IDS (35 * 43): 1500 cm2.

The sampling of surfaces was carried out by the application of "in contact" Petri dishes (Ø= 55-60 mm), with the surface of the plate slightly rounded. The contact plates allow to determine the value of Colony Forming Units (CFU) found on the area of contact between the plate and the surface concerned by sampling. The plates were used by putting them on the surface to be monitored and a slight pressure for a standard duration of 10 seconds on them has been exerted. For each surface three samples were collected, by selecting three different points for the evaluation of the average levels of contamination. A random daytime sampling protocol was applied.

The delivery to the analytical laboratory took place in the shortest time possible, in any case within 24 hours after the measurement. The plates were then placed upside down (to avoid loss of humidity, which may alter the results of the analyzes) in the thermostats and incubated in Plate Count Agar for 48-72 hours. The growth temperature and the incubation time were determined according to the standards of the guidelines in order to obtain the development of countable colonies. We proceeded with counting the number of the colonies grown. Only the bacterial colonies were counted for the evaluation of the microbiological load, with the exclusion of any fungal colonies. The plates, which after an appropriate incubation time were sterile (no growth), were reincubated at the same temperature for additional 24-48 hours in order to observe the possible development of slow-growing colonies. When the condition of sterility was found again on the plates, the final data was reported as "no growth on the surface sampled."

In each radiological department we carried out a total of 12 samples (three for each of the 4 areas considered), for a total of 144 samples. The three samples of each areas considered were then used to find an "average" value for the comparison with the other radiological departments.

*Interpretation of data*

In Italy there are no national regulations concerning exposure limits for biological agents. The American Conference of Governmental Industrial Hygienists (ACGIH) don't believe is possible to propose limit values for organic contaminants (17). In order to reach an indicative rating on the microbiological quality of the surface, we decided to compare the values obtained by the

monitoring with parameters recommended by an international guideline, the standard NF S 90-351, elaborated by a group of French public health experts collaborating with the Committee in Charge of Hospital-Borne Diseases Prevention (CLin) and introduced in France in June 2003 (18).

This document identified four hospital areas, based on the exposition level of risk infection for the patient. It also provides specific thresholds of CFU number not to be exceeded for the healthy management of specific surfaces and reports a threshold value for both areas of high and very high risk (<20 CFU).

*The questionnaire*

A short *ad hoc* questionnaire investigating the adhesion to the behavioral rules for prevention and control of biological risk was developed (Appendix 1). This questionnaire was administered by the medical staff to the radiological technicians, responsible for X-ray room. The questionnaire consisted of five questions regarding the use of hygiene measures and Personal Protective Equipment (PPE). For each measure (such as handwashing) and for each PPE the frequencies of use divided into 5 categories (Never, Rarely, Regularly, Often, Always) were investigated.

In our study, it has been considered exclusively the service area for conventional radiography, and, in particular, the room used for bone and skeletal examinations. The areas devoted to other types of radiological investigations such as CT, MRI and interventional radiology were excluded. These exclusion criteria were motivated by the need to standardize as much as possible the sampled areas and the level of risk associated, in order to ensure comparability of the results obtained from microbiological analysis.

**Results**

*Characteristics of the radiological departments*

In the 83.3% of cases, the sampled departments belong to the public National Health System (NHS). Only 2 out of 12 radiological departments were owned by private companies, accredited and

affiliated with the NHS. Furthermore, the main types of activities carried out in the departments involved in the study were assessed: in 83.3% of cases, these structures mainly performed radiological examinations in elective procedures, while 2 out of 12 departments were primarily responsible for handling requests coming from the emergency.

*Microbiological monitoring results*

The X-ray tube was found to be contaminated in 41.7% of samples, with a minimum value of 0 CFU and a maximum value of 120 CFU. The greatest number of samples above the threshold of 20 CFU was found in the Petri dishes applied to the control panels (91.7%; minimum value 6 CFU - maximum value ~ 1000 CFU) and to the imaging plates (91.7%; minimum value 7.5 CFU - maximum value 250 CFU). None of the radiological departments reported values higher than the reference threshold in the radiographic cassette and in the Image detection system - IDS (minimum value 0 CFU - maximum value 8 CFU).

About 60% of radiological departments (7/12) reported values over the threshold for three out of four samples. In 16.7% of the radiological departments only one surface presented values acceptable according to the guidelines. None of the radiological departments demonstrated the total absence of microbiological contamination. We calculated the mean value of CFU for each radiological department and the mean value, among the different radiological departments, for each surface examined. With the exception of only one Radiological Department (10.3 CFU), all the radiological departments showed an overall mean value above the threshold with a maximum value accounting for 357.2 CFU.

The results are shown in Table 1.

*The questionnaire*

We administered a short questionnaire to the chiefs of radiological departments investigating the adhesion to the behavioral rules for prevention and control of biological risk. We found that the most frequently used PPE in the various radiological departments were the gloves with an average

score of 3.3 points on a range of 1 to 5. After this PPE, the highest means were found for the clothes and the disposable hand washing, with an average score of 2.3 points.

Mean scores on PPE use declarations for each radiological department are summarized in Table 2. Only the 25% of radiological departments reached the threshold mean value of 3/5 points in the questionnaire about the adhesion to the behavioral rules for prevention and control of biological risk.

**Discussion**

The present study aimed to examine the level of microbiological contamination in twelve radiological departments of nine hospitals in Turin, in order to identify possible biological risks, both for users and health professionals, and also to assess the habits of good hygienic practices by the chiefs of departments working in these structures. Our results showed a huge prevalence of contaminated surfaces, with values of CFU out of limits in the totality of radiological departments, especially when considering the control panels and the imaging plates. These results deserve a special attention from radiologists and public health professionals (1). With the increasing number of radiological procedures and of the complexity of equipments available, indeed, the need to acquire knowledge about the prevention of healthcare-associated infections strongly emerges. Moreover, since the radiological departments do not often have the standards measures to control hospital infections, this risk of microbiological transmission is further aggravated (1). In this context, the radiological department can be considered a "high risk area" (especially "very high" in case of interventional radiological procedures) for the transmission of hospital infections.

The differences found in microbiological contamination among the surfaces examined, especially regarding the lower values measured in radiographic cassette and the IDS, can be explained by considering the sampling method and the surface characteristics. The buffer used for sampling, indeed, has a small contact area that, in the case of the radiographic cassette and IDS, may not be

sufficient for a proper collection of the sample. Moreover, a single radiographic cassette is not used on all patients, so the opportunities for contamination decrease. Furthermore, we should consider that, in the majority of cases, the examinations are carried out by using an anti-diffusion grid and therefore not in direct contact with the patient. Notably, the highest values of microbiological contamination were found in some samples collected on control panels in four radiological departments (ID: 1, 6, 7, 8). In this regard, we searched possible explanations for this result and we found that in 3 of 4 radiological departments the cleaning service of the control panels was not carried out by the technical staff, but by the auxiliary staff.

In addition, our results showed a dangerous lack of attention to the adhesion to the behavioral rules for prevention and control of biological risk by the chiefs of radiological departments. These data confirm previous literature that highlighted how physicians, nurses and technologists working in radiological departments usually lack knowledge and skills concerning asepsis and antisepsis (8). Considering that our results are based on the answers reported by the chiefs of the radiological departments, we can hypothesize a similar, or maybe a worse, behavior among technologists and the other health professionals who do not hold apical positions.

To the authors' knowledge, this is the first study of its kind in the radiological literature. However, this study has also some limitations that should be considered when interpreting the results. The levels of microbial concentration determined in this way are only approximations of the transient concentrations of microorganisms in the air. The current environmental conditions and the same sampling technique, indeed, can stress and/or damage the microbial cells with a reduction of their culturability in the laboratory despite the maintenance of their vitality. Therefore only vital and cultivable micro-organisms can be counted and it is hypothesized an underestimation of the actual microbial concentration.

In conclusion, healthcare-associated infections are a cogent and important issue not only for public health professionals but also for the radiologists. This study meant to be a first analysis of the issue,

like a pilot study highlighting the need of further investigations, maybe with the characterization of the microbial species involved. Considering that the adherence to standard precautions is not uniform, and incorrect practices responsible for preventable infections persist, we suggest the implementation of appropriate institutional policies and the development of shared and official standards for the evaluation of microbiological contamination in Radiological Departments.

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**Table 1.**

**Microbiological sampling - Number of Colony Forming Units (CFU) according to surface of sampling.**

| Radiology Department | X-ray Tube | Control Panel | Imaging Plate | Radiographic Cassette and Image Detection System | Mean |
|---|---|---|---|---|---|
| | *CFU* | *CFU* | *CFU* | *CFU* | |
| 1 | 10 | 300 | 250 | 0 | 186.7 |
| 2 | 20 | 100 | 250 | 1 | 123.3 |
| 3 | 35 | 80 | 30 | 3 | 48.3 |
| 4 | 30 | 20 | 22,5 | 1 | 24.2 |
| 5 | 120 | 40 | 250 | 1 | 136.7 |
| 6 | 9 | 1000 | 62.5 | 1 | 357.2 |
| 7 | 50 | 600 | 125 | 1 | 258.3 |
| 8 | 10 | 1000 | 7.5 | 1 | 339.2 |
| 9 | 2 | 70 | 100 | 3 | 57.3 |
| 10 | 0 | 6 | 25 | 1 | 10.3 |
| 11 | 14 | 50 | 25 | 2 | 29.7 |
| 12 | 5 | 100 | 50 | 8 | 51.7 |
| **Mean** | 25.4 | 280.5 | 99.8 | 1.7 | 135.2 |

**Table 2. Mean score of Personal Protective Equipment (PPE) use**.

| Radiologic Departments | Handwashing* | Disposable gloves | Disposable towel | Other PPE^ | Mean score |
|---|---|---|---|---|---|
| 1 | 2 | 5 | 1 | 1 | 2.25 |
| 2 | 2 | 3 | 1 | 2 | 2 |
| 3 | 3 | 2 | 2 | 1 | 2 |
| 4 | 4 | 5 | 1 | 3 | 3.25 |
| 5 | 2 | 1 | 1 | 1 | 1.25 |
| 6 | 2 | 3 | 2 | 3 | 2.5 |
| 7 | 1 | 2 | 1 | 3 | 1.75 |
| 8 | 2 | 2 | 5 | 1 | 2.5 |
| 9 | 3 | 5 | 3 | 3 | 3.5 |
| 10 | 3 | 4 | 4 | 3 | 3.5 |
| 11 | 2 | 2 | 3 | 1 | 2 |
| 12 | 2 | 5 | 4 | 3 | 3.5 |
| **Mean** | 2.3 | 3.3 | 2.3 | 2.1 | - |

* handwashing before and after contact with patients and/or equipment, according with the CDC recommendations (5).
^ scrubs, protective masks and visors
Scoring: 1: never; 2: rarely; 3: regularly; 4: often; 5: always.