

# Analysis of Healthcare Convergence on Bacterial Contamination of Radiological Equipment in Emergency Rooms of General Hospitals

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## 종합병원 응급실내의 영상의학과 장비에서의 세균 오염에 관한 보건학적 융합 분석

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**Abstract** It is to establish preliminary data about healthcare convergence of infection control by performing a bacterial contamination test for CT scanner as well as general radiographic systems in the emergency rooms of general hospitals. The period was December 1 ~ December 31, 2015. It is detect in the emergency rooms of 7 medical facilities including 2 in Seoul, and 1 in Gyeonggi-do Province, and 2 in Jeolla-do Province, and 2 in Chungcheong-do Province. The surface contamination strains detected from CT scanner in the radiology department emergency rooms were *Micrococcus* species(4.5%), *Stenotrophomonas maltophilia*(9%), *Enterococcus faecium*(4.5%), *Providencia stuartii*(4.5), and Gram negative bacilli(4.5%). Also, the surface contamination strains detected from general radiographic system in the radiology department emergency rooms were *Providencia stuartii*(11%), *Klebsiella pneumonia*(3.5%), *Stenotrophomonas maltophilia*(11%), *Pantoea* species(11%), *Acinetobacter baumannii*(3.5%), *Micrococcus* species(3.5%), *Escherichia coli*(3.5%), *Enterobacter* species(3.5%), and Gram negative bacilli(11%). Considering that the regions of most detection were all the places closely related to patients, radiologists would have to thoroughly clean with alcohol before and after a test.

• **Key Words** : Computed tomography, Radiology, Bacteria, Infection, Emergency room, Healthcare convergence

**요약** 본 연구는 종합병원 내 응급실에 설치된 CT 장비와 일반촬영장비에 대한 세균 오염도 검사를 실시하여 보건학적 융복합 감염관리에 대한 기초자료를 마련하고자 하였다. 연구는 2015년 12월 1일부터 12월 31일까지 수도권 3곳과 전라도 2곳, 충청도 2곳 등 총 7곳의 의료기관을 대상으로하였다. 영상의학과 응급실 내 CT장비의 검출된 표면 오염 균주는 *Micrococcus* species(4.5%), *Stenotrophomonas maltophilia*(9%), *Enterococcus faecium*(4.5%), *Providencia stuartii*(4.5), Gram negative bacilli(4.5%), 일반촬영장비에서 검출된 표면 오염 균주는 *Providencia stuartii*(11%), *Klebsiella pneumonia*(3.5%), *Stenotrophomonas maltophilia*(11%), *Pantoea* species(11%), *Acinetobacter baumannii*(3.5%), *Micrococcus* species(3.5%), *Escherichia coli*(3.5%), *Enterobacter* species(3.5%), Gram negative bacilli(11%) 로 병원 감염의 원인균으로 알려진 균주는 없었고, 특이성을 가진 균주 역시 없었지만 가장 많이 검출된 구역이 모두 환자와 밀접한 관련을 갖는 곳이므로 방사선사는 검사 전후 알코올 등으로 깨끗이 닦아내야 할 것이다.

• **주제어** : 전산화단층촬영, 일반촬영, 박테리아, 감염, 응급실, 보건학적 융합

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## 1. Introduction

Recently, the recognition of infection is increasing. Particularly, as healthcare providers are readily exposed to infectious sources, disinfection and sterilization are required in cross- and contact-infection. Although radiology department is characterized with not only a short distance of patients' contact but also easy infection from patients, many people have misconceptions that there is no problem about disease development considering the hospital system with high care accessibility [1,2,3,4]. However, considering the incidence of MERS(Middle East Respiratory Syndrome) occurred in one of the most privileged university hospitals in Korea in summer of 2015, the role of infected healthcare providers as a vector is not negligible, and it raised the significance of infection control once more[5].

Radiologists are at high risk of cross-infection because of the contact with a number of many patients in various areas including magnetic resonance image (MRI), fluoroscopy, general x-ray, computed tomography (CT), mammography, and ultrasonography [6]. The infection of radiologists becomes a secondary infection source and a cause to infect other staff or patients. The Ministry of Health and Welfare made the establishment of infection control committee mandatory as measures for a secondary infection, nosocomial infection, which should be reported to the Minister of Health and Welfare immediately upon its incidence in Korea[7]. However, most radiology departments are often not included for the management, and it cannot help being neglected in infection control because of the urgency to treat emergency patients. For this, hand contamination of not only patients visiting emergency department but also caregivers and workers should be raised for concern.

Nosocomial infection refers to the infection developing after hospital admission/discharge, and is a local or systematic symptom, being resulted from the reaction to toxin(s) in addition to infectious material(s) [8][9]. Recently, the significance is being raised in quality control, and the measures and prevention of

infection is considered as a core factor [10,11]. Particularly, chest x-ray, accounting for a great proportion as 27.5% of the entire general radiographic exams, is a basic test to most patients visiting emergency room as it provides plenty of information about lungs and heart [12], most severe patients visiting emergency room undergo CT scan. As patients with various infection sources visit and contact the radiology examination room in emergency department, strict infection control is required and should take the recognition of hospital infection control into high consideration [13].

Because currently there is no infection research about CT room, a closed space due to the characteristics of the test, and particularly there is a lack of study about the department of radiology in emergency room, it is essential to perform research about this.

Therefore, this study investigated both the areas of workers and patients in order to comprehend the reality of infection control about CT room, which accounts for the most of severe patients, and general radiographic room, which is considered for a basic exam, among the tests of radiology in emergency room. This study is designed to investigate the infection status including contamination and hygiene of CT room and general radiographic room in emergency room based on the identified bacteria and to suggest the significance of infection control of workers as well as patients, and the necessity of education.

## 2. Methods

### 2.1 Materials and Method

#### 2.1.1 Materials

For sample collection, 7 medical facilities were selected 2 in Seoul, and 1 in Gyeonggi-do Province, and 2 in Jeolla-do Province, and 2 in Chungcheong-do Province, which all performed at least 30 tests daily, and CT scanner as well as general radiographic systems in the emergency rooms were set to be selected instruments.

The period was december 1 ~ december 31, 2015, and for CT scanner, samples were taken from the top of exposure controller used by radiology workers most, and 3 places including x-ray exposure button, the entire top of patient table which a patient's skin is in contact with, and the inside of bore [Fig. 1].

For general x-ray, samples were taken using sterilized transport medium cotton swabs in order of top, middle, and bottom from 4 places including the top of exposure controller used by radiology workers most, exposure button, the entire top of patient table, which a patient's skin is in contact with, and grid of stand bucky and chin support[Fig. 2].



[Fig. 1] Sample collection from 3 places in CT room of radiology department, sample collection from CT scanner exposure controller (A), inside of bore (B), patient table (C).



[Fig. 2] Sample collection from 4 places in general x-ray room in the radiology department, sample collection from exposure controller (A), patient table (B), stand bucky-chin support (C) and stand bucky-grid (D) of general radiographic system.

The tips of Transport medium cotton swabs used after sample collection were placed in individual sample tubes containing transport medium(YH003, Yuhan labtech, Korea) and then sealed. The sealed samples were classified by collection areas within 24hrs, requested for identification in commercial laboratory tests, inoculated and cultured according to the standards of microorganism test [14], and the identification results were obtained by a laboratory medicine physician.

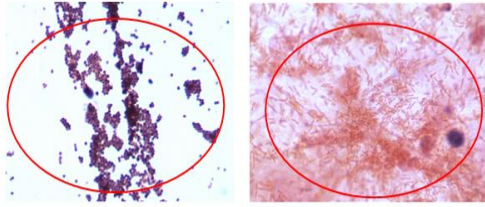
### 2.1.2 Culture

After the tip of a cotton swab was placed in an individual sample tube containing transport medium YH003, Yuhan labtech, Korea) and cultured in 37°C incubator for 24hrs, 1cc of the medium that the sample was dipped into was inoculated to each of Blood Agar Plate (BAP: Asan pharmaceutical.Korea) and MacConkey Agar Plate(Mac: Asan pharmaceutical.Korea) for bacterial proliferation and cultured in 37°C incubator for 24hrs. After 24 hrs of culturing, the presence or absence of colony formation was checked [Fig. 3]. For the cultured colonies, Gram stain was performed for screening[Fig. 4].

As a result of gram stain, the final identification of bacteria was performed by API 20 Strep(BioMerieux SA,France) for gram Postive cocci, and by API 20 E (BioMerieux SA,France) for gram negative bacilli and enterobacteriaceae.



[Fig. 3] Blood Agar Plate (BAP) and MacConkey Agar Plate(MAC)



[Fig. 4] Gram positive stain, gram negative stain slide X1000

### 3. Results

#### 3.1 CT

##### 3.1.1 Bacterial strains detected from CT scanner

When a contamination test was performed in 3 places of CT scanner including exposure controller, top of a patient table, and inside of bore, in emergency room of 7 hospitals, more than 1 bacteria were detected in 4 hospitals, and no bacteria were detected in 2 in Seoul, and 1 in Gyeonggi Province. The detected strain of surface contamination were *Micrococcus species*, *Stenotrophomonas maltophilia*, *Enterococcus faecium*, *Providencia stuartii*, and *Gram negative bacilli*, which were known to be causal strains of hospital infection, and no strains exhibited unusual phenominon <Table 1>.

<Table 1> Types of detected bacteria

H.	Collection site	detected bacteria
A	Inside of bore	No growth in 2 days
	Patient table	<i>Micrococcus species</i>
	Exposure controller	No growth in 2 days
B	Inside of bore	<i>Stenotrophomonas maltophilia</i> , <i>Enterococcus faecium</i>
	Patient table	<i>Providencia stuartii</i>
	Exposure controller	No growth in 2 days
C	Inside of bore	No growth in 2 days
	Patient table	<i>Gram negative bacilli</i>
	Exposure controller	No growth in 2 days
D	Inside of bore	No growth in 2 days
	Patient table	No growth in 2 days
	Exposure controller	No growth in 2 days
E	Inside of bore	<i>Stenotrophomonas maltophilia</i>
	Patient table	No growth in 2 days
	Exposure controller	No growth in 2 days
F	Inside of bore	No growth in 2 days
	Patient table	No growth in 2 days
	Exposure controller	No growth in 2 days
G	Inside of bore	No growth in 2 days
	Patient table	No growth in 2 days
	Exposure controller	No growth in 2 days

##### 3.1.2 Distribution of detected strains from CT scanner

In terms of the distribution of detected bacteria, *Stenotrophomonas maltophilia* was most common with 2 collection sites of inside of bore B and E hospital accounting for about 9%, and *Micrococcus species*, *Enterococcus faecium*, *Providencia stuartii*, and Gram negative bacilli were found in 1 case respectively, each accounting for 4.5%. Also, the bacteria which did no growth in an incubator after 48 hours were 16 collection sites, accounting for about 73%, and no strains were detected in most places <Table 2>.

A bacteria was not detected in the exposure controller at all among the places of sample collection, and the rest of places were similar. Also, the most commonly detected *Stenotrophomonas maltophilia* was not detected in exposure controller at all, but most commonly detected in the inside of bore.

<Table 2> Number of bacteria by each sample collection site

Bacteria	Collection site			Total N (%)
	Inside of bore (A)	Patient table (B)	E. control ler(C)	
<i>Stenotrophomonas maltophilia</i>	2	0	0	2 (9)
<i>Micrococcus species</i>	0	1	0	1 (4.5)
<i>Enterococcus faecium</i>	1	0	0	1 (4.5)
<i>Providencia stuartii</i>	0	1	0	1 (4.5)
Gram negative bacilli	0	1	0	1 (4.5)
No growth in 2 days	5	4	7	16 (73)
<b>Sum(except No growth in 2 days)</b>	<b>3</b>	<b>3</b>	<b>0</b>	<b>22 (100)</b>

#### 3.2 General radiographic device

##### 3.2.1 Bacterial strains detected in general radiographic device

In the general radiographic device in emergency room of 7 medical facilities, a contamination test was performed in 4 places including stand bucky-grid, stand bucky-chin support, the top of patient table, and exposure controller. Consequently, more than 1

bacterial strain were detected in 5 medical facilities, and no bacteria were detected in all placed in 1 seoul and 1 keonggi province. The detected strains of surface contamination were *Providencia stuartii*, *Klebsiella pneumonia*, *Stenotrophomonas maltophilia*, *Pantoea species*, *Acinetobacter baumannii*, *Micrococcus species*, *Escherichia coli*, *Enterobacter species*, and other gram negative bacilli, which were known to be causal bacteria of hospital infection, and none of them exhibited unusual phenominon <Table 3>.

<Table 3> Types of detected bacteria

H.	Collection site	detected bacteria
A	Stand bucky-grid	<i>Providencia stuartii</i>
	Stand bucky-chin support	<i>Klebsiella pneumoniae</i>
	Patient table	Gram negative bacilli
	Exposure controller	<i>Providencia stuartii</i>
B	Stand bucky-grid	no growth in 2 days
	Stand bucky-chin support	<i>Pantoea species</i>
	Patient table	Gram negative bacilli
	Exposure controller	<i>Pantoea species</i>
C	Stand bucky-grid	<i>Acinetobacter baumannii</i>
	Stand bucky-chin support	<i>Pantoea species</i>
	Patient table	<i>Providencia stuartii</i>
	Exposure controller	no growth in 2 days
D	Stand bucky-grid	<i>Micrococcus species</i>
	Stand bucky-chin support	Gram negative bacilli
	Patient table	<i>Stenotrophomonas maltophilia</i>
	Exposure controller	<i>Stenotrophomonas maltophilia</i>
E	Stand bucky-grid	<i>Escherichia coli</i>
	Stand bucky-chin support	<i>Enterobacter species</i>
	Patient table	<i>Stenotrophomonas maltophilia</i>
	Exposure controller	no growth in 2 days
F	Stand bucky-grid	no growth in 2 days
	Stand bucky-chin support	no growth in 2 days
	Patient table	no growth in 2 days
	Exposure controller	no growth in 2 days
G	Stand bucky-grid	no growth in 2 days
	Stand bucky-chin support	no growth in 2 days
	Patient table	no growth in 2 days
	Exposure controller	no growth in 2 days

### 3.2.2 Distribution of detected strains from CT scanner

In terms of the distribution of detected bacteria, *Providencia stuartii* and *Stenotrophomonas maltophilia*,

gram negative bacilli, and *Pantoea species* were most common with 3 collection sites of stand bucky-chin support(B,C) and exposure controller(B) accounting for about 11%, and *Klebsiella pneumonia*, *Acinetobacter baumannii*, *Micrococcus species*, *Escherichia coli*, and *Enterobacter species* were 1 case respectively, each accounting for 3.5%. Also, the bacteria which did no growth in an incubator after 48 hours were 11 cases, accounting for about 38.5%, and no strains were detected in most places <Table 4>.

The most commonly detected *Stenotrophomonas maltophilia* and gram negative bacilli were detected mostly in patient table. While *Providencia stuartii* was detected similarly in all places except stand bucky-chin support, *Pantoea species* was detected mostly in stand bucky-chin support.

<Table 4> Number of bacteria by each sample collection site

Bacteria	Collection site				Total N(%)
	S.T-grid (A)	S.T-chin support (B)	P. table (C)	E. contro ller (D)	
<i>Providencia stuartii</i>	1	0	1	1	3 (11)
<i>Stenotrophomonas maltophilia</i>	0	0	2	1	3 (11)
<i>Pantoea species</i>	0	2	0	1	3 (11)
<i>Klebsiella pneumonia</i>	0	1	0	0	1 (3.5)
<i>Acinetobacter baumannii</i>	1	0	0	0	1 (3.5)
<i>Micrococcus species</i>	1	0	0	0	1 (3.5)
<i>Escherichia coli</i>	1	0	0	0	1 (3.5)
<i>Enterobacter species</i>	0	1	0	0	1 (3.5)
Gram negative bacilli	0	1	2	0	3 (11)
no growth in 2 days	3	2	2	4	11 (38.5)
<b>Sum(excpt No growth in 2 days)</b>	<b>4</b>	<b>5</b>	<b>5</b>	<b>3</b>	<b>28 (100)</b>

## 4. Conclusions and Discussions

Currently in Korea, as anxiety about the infection of

strongly resistant bacteria is growing due to MERS incidence, accurate comprehension about the real situation and intense infection control are required. Lately, the increase of antibiotic resistance due to overuse of antibiotics is considered as a cause of increased hospital infection [15].

As a result of test in emergency rooms of 7 hospitals, bacteria were detected in 4 emergency CT rooms and 5 general radiographic rooms. As in a previous studies [18] were detected as isolated bacteria, of which Methicillin Resistant coagulase-negative Staphylococci(MRCNS) were detected in 15 cases(62.5%), which was most. But in contrast to previous studies, *Staphylococcus epidermidis* was not detected [16,17,18]. *Staphylococcus epidermidis* is one of Staphylococcus, non-pathogen, and not food poisoning-induced. However, it sometimes cause endocarditis, urethritis, and sepsis, and it is not negligible as it can cause severe diseases to immunosuppressed patients as lately resistance to methicillin and penicillin G has developed [19]. Fortunately, unlike previous studies[16,17,18], it is supposed that the hygiene condition was relatively good despite the mobility of many patients, no detection in emergency CT room and general radiographic room.

*Stenotrophomonas maltophilia* is the most commonly detected bacteria, gram negative, and not highly pathogenic. However, it forms biofilm on the surface of medical devices as well as pulmonary epithelial cells, has great influence in respiratory infection, and is becoming multi-drug resistant [20,21,22]. As the study of Araoka et al. has reported that pneumonia due to *Stenotrophomonas maltophilia* in hematologic cancer patients has 100% mortality, it can cause lethal result in immunosuppressed patients though its pathogenicity is low [23,24]. It is worth paying attention to that lately, nosocomial infection of *Stenotrophomonas maltophilia* is increasing through medical devices inserted after surgery [25], and the detection rate of *Stenotrophomonas maltophilia*, which is strongly antibiotic-resistant[20], is high in the testing devices in emergency room,

which is often an entrance and exist of immunosuppressed patients. It is also important to take note of high detection rate in the inside of bore, which is close to patient's respiration and thus radiologists should often clean exposed areas with alcohol before and after tests.

The next commonly detected *Providencia stuartii* is one of 5 *Providencia*, exists mostly in soil and water, and causes urethritis [26]. *Klebsiella pneumoniae* is a bacteria of respiratory infection[27], and can be readily infected in immunosuppressed patients like *Stenotrophomonas maltophilia* [22,23].

As in a previous study [4], bacteria were often detected in exposure controller including exposure button and grid in this study. Because this indicates that infection can transmitted by hands of radiologists, activities such as hand-washing after a test [28] in addition to disinfection with alcohol cotton balls should be performed to prevent secondary hospital infection. Other than that, it is to be aware of that *Escherichia coli* and *Enterococcus faecium*, which are enterococcus, can cause urethral infection or food poisoning although their pathogenicity is low [29].

This study is designed to investigate infection control for testing devices in radiology department in emergency room of general hospitals. Its purpose is to investigate the factors to cause infectious diseases in immunosuppressed patients or hospital staff, and reduce nosocomial infection. This would be a new fact-finding investigation about infection control, which is a common subject of public health. It should be recognized that increasing the recognition about the infection of testing devices and reducing nosocomial infection are very important not only for patients but also for the health of healthcare providers [30,31].

According to the study of Laura et al.[32], when the number of patient contact and hands are not washed, nosocomial infection is 3 times higher than other groups, and particularly radiologists is a professional group actively participating in diagnosis and treatment in hospitals and thus are in greatest contact with

patients [18,28,33]. Therefore, radiologists' compliance to strict infection control and prevention measures would play a pivotal role in minimizing the incidence of nosocomial infection [34].

The role of healthcare providers is significant to effectively prevent the spreading of infection [35]. Since the emergency room of a general hospital is a place where highly immunosuppressed patients come in and out, severe diseases caused by the bacteria detected in this study is highly plausible in development. Although detected strains do not exhibit unusual phenomena, radiologists, who are most exposed to the risk of nosocomial infection, should raise awareness of the importance of disinfection, and there should be a change in perception of infection control in hospitals, prioritizing medical staff infection in terms of hospital infection prevention. After further research and to study for the infection to other hospital equipment.

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