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High Isolation Frequency of *Acinetobacter baumannii* from Physical Therapy Departments of Geriatric Care Hospitals and Antibiotic Resistance Patterns of Isolated Pathogens

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Abstract. [Purpose] Though geriatric care hospitals are continuously increasing due to the expansion of the elderly population, studies of hospital-acquired infections in their physical therapy rooms are currently lacking. This study examined the isolation frequency and antimicrobial resistance of bacterial pathogens isolated from physical therapy rooms of geriatric care hospitals. [Methods] Specimens were collected from physical therapy rooms of geriatric care hospitals The isolates were examined by morphological and biochemical tests, 16S rRNA analysis and antimicrobial susceptibility tests. [Results] Among *Enterobacteriaceae*, *Acinetobacter baumannii* was the major pathogen in the physical therapy rooms, followed by *Serratia marcescens*, *Enterobacter cloacae*, *Escherichia coli*, *Klebsiella ozaenae* and *Klebsiella oxytoca* in order of frequency of occurrence. Among non-fermenting Gram-negative rods, *Pseudomonas fluorescens*, *Pseudomonas aeuroginosa*, and among Gram-positive cocci, *Enterococcus feacalis* and *Staphylococcus* sp. were detected in order of frequency of occurrence. Gram-positive bacilli and fungus were also detected. *A. baumannii* isolates showed strong resistance to cephalothin and ampicillin. *Enterobacteriaceae* isolates showed strong resistance to ampicillin, ampicillin/sulbactam, cefazolin and cefoxitin. *Staphylococcus* spp isolates were methicillin-resistant coagulase-negative *Stapylococcus* spp (MR-CNS). [Conclusion] The results suggest the possible appearance of multidrug-resistant bacteria. To control nosocomial infections in physical therapy rooms of geriatric care hospitals and to prevent multidrug-resistant bacteria, continuous investigation and hygiene control are required.

Key words: Physical therapy room, *Acinetobacter baumannii,* Multidrug-resistant bacteria

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INTRODUCTION

The elderly population of Korea is expanding and society should prepare for the expansion of the aging population in advance. An aging society is one in which the proportion of the population over 65 years old is over 7%, an aged society is one which it is over 14%, and a super-aged society is one in which it is over 20%. Our society, which is an aging society, will be an aged society by 2018, and a super-aged society by 2026. We should consider how fast our population is aging. It took 92 years for the United Kingdom to become a super-aged society, 80 years for Germany, and 36 years for Japan. South Korea already has an aging society, and will take 18years to transition from an aging society to an aged society and 8 years to transition from an aged society to a super-aged society, much faster than other countries[1,2)]. We all need to recognize the seriousness of the present situation and prepare for the future.

The number of people over 65 years of age was 4.367 million in 2005, 4.4 times the 0.911 million in 1970. People over 65 years of age will account for 16.156 million persons in 2050[3)]. Because of aging and the development of medical technology, deaths from acute disease are reducing, but chronic degenerative diseases are increasing. Chronic diseases due to advanced age often result in secondary injury. The incidence rate of injury among those aged over 65 years is two times than people under 65 years. The number of small families is increasing. Old patients who need long-term care and suffer from handicaps are increasing and geriatric care hospitals are also increasing[4)].

The number of geriatric care hospitals has increased from 203 in 2005 to 591 in 2007 due to the growing numbers of aged people with chronic diseases[5)]. However,

no study of the microorganism infections or antibiotic resistance rates in geriatric care hospitals has been conducted, despite there being many studies about foreign long-term care facilities. The isolation ratio of methicillin resistant *Staphylococcus aureus* (MRSA) is 2.4% in Germany, 9.3% in Slovenia, 16% in Spain, and 22% in the UK[6–8]. In countries which became an aging society earlier than us, studies of mass infections and antibiotic resistance of MRSA, vancomycin resistant *Enterococci* (VRE) and extended spectrum β-lactamase (ESBL) producing Gram negative rod bacilli in long-term care facilities (LTCFs) have been conducted. Moreover, manuals for controlling infections have been developed for use in LTCFs[9–12].

The possibility of hospital-acquired infection in geriatric care hospitals is very high, because of the high demand for physical treatment, long-stay in treatment rooms, physical contact with physicals therapist and the common use of instruments and rooms. However, no specific study of microorganism infections contracted from physical therapy in geriatric care hospitals has been conducted in South Korea. Investigations about bacterial pathogens in therapy rooms are needed to establish an infection control manual to prevent hospital-acquired infection and cross-infection among patients. In this study, we studied the status of microorganisms and antibiotic resistance patterns of pathogens isolated from physical therapy rooms of geriatric care hospitals.

SUBJECTS AND METHODS

Specimens were collected at physical therapy departments in six general hospitals in Busan using transport media. The specimens were divided into three groups by sources. The first group was therapeutic environments including physical therapists' hands, treatment tables, pillows, and floor. The second group was wet therapeutic equipment including electrodes for transcutaneous nerve electrical stimulation (TENS), electrodes for interferential current therapy (ICT), electrodes for electrical stimulation therapy (EST), therapeutic baths, hot pack units, and moist hot packs. The third group was dry therapeutic equipment including ultrasound transducer heads, electrical hot packs, therapeutic balls, grips of pulleys, grips of shoulder wheels and grips of wrist roll.

The transport media containing specimens were moved to the laboratory where we isolated microorganisms from the transport media. The transport media were stored at room temperature and the specimens were cultured on growth media such as blood agar plates (BAP), MacConkey's (MAC) and chocolate agar plates (CAP), or in enrichment broth such as tryptic soy broths (TSB). They were incubated for 24~48 hours until bacterial colonies were formed. The cultures were carried out under aerobic and anaerobic conditions.

The isolated bacteria were stained by Gram stain, tested by oxidase and catalase tests, and identified using API kits or Vitek GPI (for Gram-positive bacteria, bioMerieux) or Vitek GNI (for Gram-negative bacteria) kits. The identified bacteria were confirmed through more accurate serologic reactions or biochemical tests. Genotype analysis of the identified and unidentified bacteria were conducted using 16s RNA, 23s RNA and DNA gyrase. Genomic DNA was extracted using Accuprep Genomic DNA extraction kits (Bioneer, Seoul, Korea). Bacteria were dissolved in 5ml of TSB and cultured for 24 hours at 37°C. Aliquots of the cultured bacteria, 1.5 ml, were transferred to an E-tube and centrifuged for 2 min at 8,000 rpm to completely remove the supernatant fluid. TE buffer, 200 µl , 10 µl of proteinase K (20mg/mL) and 200 µl of binding buffer GC were then added to the pellet and incubated for 10 minutes in a hot block at 60°C. Isopropanol, 100 µl , was added to the solution which was then transferred to a column and centrifuged for 1 min at 8,000 rpm. The column was washed with 500 µl of washing buffer 1 (W1) and centrifuged for 1 min at 8,000 rpm. After a second wash with 500 µl of washing buffer 2 (W2) and centrifugation, the column was centrifuged for 2 min at 12,000 rpm to remove residual ethanol. The column was then moved to a new E-tube and 200 µl of elution buffer (10 mM Tris-HCl, pH 8.0) was added. The E-tube was left to stand for at least 5 min at room temperature, and then centrifuged for 1 min at 8,000 rpm for elution of the DNA which was used as a PCR template.

Primers for 16S rRNA, 23S rRNA, and DNA gyrase genes were made using the primers designed by Kim[13]. The solution for PCR reactions was made using the AccuPower PCR Premix Kit (Bioneer Co. Ltd. Seoul, Korea) by adding 0.5µl of DNA sample (25 ng), 1 µl of primer (10 pmol) and distilled water up to 20 µl . The PCR reaction conditions consisted of a 5 min initial reaction at 94°C followed by 30 cycles of 30 seconds at 94°C, 30 seconds at 51.3°C and 2 min at 72°C. A final extension at 72°C for 7 min completed the PCR. After we separated bands by electrophoresis, individual amplified products were purified using Accuprep gel purification kit (Bioneer Co. Ltd. Seoul, Korea). Then, the purified DNA was analyzed by DNA sequencing. The genotypes of the isolates were determined by BLAST analysis of the obtained base sequences.

The antimicrobial susceptibility test of the isolates was tested using Vitek GPS-450 and 451 kits (bioMerieux) in the case of Gram-positive bacteria and Vitek GPS-433 and 434 kits, or the disk diffusion method, in the case of Gram-negative bacteria. The media used for antibiotic tests used were Müller Hinton agar or BAP and antibiotics that are associated with most cases of hospital-acquired infections were used. The bacteria were dissolved into tryptic soy broth (TSB) and cultured for 1~2 hours to make a bacterial suspension with a turbidity of MacFarland No. 0.5. The suspension was evenly smeared on Müller Hinton agar using swabs and an antibiotic disk was placed on it. The bacteria were cultured for 18~24 hours at 37°C and their resistances to antibiotics were determined by measuring the diameter of the inhibition zone around the antibiotic disks. The isolation ratios of the isolates showing antibiotic resistance were statistically analyzed.

RESULT

A total of seventy two specimens were collected from the physical therapy departments of six geriatric hospitals.

Table 1. Antimicrobial resistance (%) of non-fermenters isolated from physical therapy departments of geriatric care hospitals

Gram-negative rods (Nonfermenters)	*A. baumannii* (36%)	*Pseudomonas spp* (5.6%)
Amikacin	6.3	0
Ampicillin	78.1	60
Ampicilln/Sulbactam	43.8	60
Aztreonam	32	40
Cefepime	0	0
Ceftazidime	6.3	0
Ceftriaxone	18.8	20
Cephalothin	90.6	100
Ciprofloxacin	3.1	0
Gentamicin	3.1	20
Imipenem	6.3	20
Piperacillin	0	0
Piperacillin/Tazobactam	0	0
Ticarcillin/Clavulanic acid	9.4	40
Tobramycin	9.4	20
Trimeth/Sulfa	6.3	40

Table 2. Antimicrobial resistance (%) of Enterobacteriaceae isolated from physical therapy departments of geriatric care hospitals

Gram-negative rods *(Enterobacteriaceae)*	*E.coli* (6.7%)	*E.cloacae* (9.0%)	*S.marcescens* (11.2%)
Amikacin	0	0	0
Ampicillin	16.7	100	70
Ampicilln/Sulbactam	0	75	30
Aztreonam	0	12.5	10
Cefazolin	33.3	75	100
Cefepime	0	12.5	0
Cefoxitin	0	100	30
Ceftriaxone	0	0	10
Ciprofloxacin	0	0	0
Gentamicin	0	0	10
Imipenem	0	0	0
Piperacillin/Tazobactam	0	25	0
Tobramycin	0	0	10
Trimeth/Sulfa	0	12.5	10

Table 3. Antimicrobial resistance (%) of Gram-positive cocci isolated from physical therapy departments of geriatric care hospitals

Gram-positive cocci	*E. feacalis* (6.7%)	Gram-positive cocci	*Staphylococcus spp* (8.9%)
Ampicillin	0	Cephalothin	100
Chloramphenicol	80	Ciprofloxacin	0
Ciprofloxacin	0	Clindamycin	75
Gentamicin-500	60	Erythromycin	75
Imipenem	0	Gentamicin	25
Nitrofurantoin	0	Nitrofurantoin	0
Penicillin G	40	Oxacillin	100
Streptomycin-2000	60	Penicillin G	100
Tetracycline	80	Tetracycline	25
Vancomycin	0	Trimeth/Sulfa	12.5
Quinupristin/ Dalfopristin	80	Vancomycin	0
Teicoplanin	60	Habekacin	0
		Linezolid	0
		Rifampin	12.5
		Teicoplanin	12.5

A total of twenty three different specimens were collected from the therapeutic environments. The most isolated bacteria were *Acinetobacter baumannii* (*A. baumannii*) (36.0%). Among *Enterobacteriaceae, Serratia marcescens* (*S. marcescens*) (11.2%), *Enterobacter cloacae* (*E. cloacae*) (9.0%), *Escherichia coli* (*E. coli*) (6.7%), *Klebsiella ozaenae* (1.1%), and *Klebsiella oxytoca* (1.1%) were isolated. Among non-fermentation Gram-negative rods, *Pseudomonas fluorescens* (3.4%), and *Pseudomonas aeruginosa* (2.2%) were isolated. Among Gram-positive cocci, *Enterococcus feacalis* (*E. faecalis*) (6.7%), *Staphylococcus sciuri* (5.6%), *Staphylococcus hominis* (2.2%), and *Staphylococcus capitis* (1.1%) were isolated. Gram-positive bacilli (12.4%) and fungi (1.1%) were also isolated. *A. baumannii* and *E. coli* were isolated with the highest frequencies from all therapeutic environments.

A total of twenty two specimens were collected from the wet therapeutic equipment. The majority of the microorganisms isolated from these specimens were *A. bauumannii* (33.3%) and *E. feacalis/Enterobacter cloacae* (16.7%). *Serratia marcescens*, *Klebsiella ozaenae*, *Pseudomonas fluorescens*, *Staphylococcus hominis*, and *Staphylococcus capitis* were also detected.

A total of thirty one specimens were collected from the dry therapeutic equipment. The majority of the microorganisms isolated from these specimens were *Acinetobacter bauumannii* (48.6%). *Enterobacter cloacae, Serratia marcescens*, *E. coli*, *Klebsiella oxytoca*, *E. feacalis, Staphylococcus sciuri*, *Staphylococcus hominis* and Gram positive bacilli were also detected. *A. baumannii* was isolated with the highest frequency from all dry therapeutic equipment.

The majority of the microorganisms detected in physical therapy rooms of geriatric care hospitals were *A. baumannii.* They were resistant to ceftazidime (6.3%), imipenem (6.3%), amikacin (6.3%), ciploxacin (3.1%), and tobramycin (9.4%). They showed highest antibiotic resistance to cephalothin (90.6%) and ampicillin (78.1%) (Table 1). The frequency of *Enterobacteriaceae* was 29.1% and they showed high resistance to ampicillin, ampicillin/sulbactam, cefazolin, and cefoxitin (Table 2). *E. faecalis* were isolated occasionally, and they showed the highest antibiotic resistance. *Staphylococcus* spp were found as methicillin-resistant coagulase-negative *Staphylococcus* (MR-CNS) but not as MRSA (Table 3).

DISCUSSION

In this study, we isolated microorganism pathogens and characterized their antibiotic resistance from therapeutic environments, wet therapeutic equipment and dry therapeutic equipment in physical therapy department. The most

isolated bacteria in all groups were *A. baumannii* (36%), followed by *S. marcescens*, *Staphylococcus* spp, *E. cloacae*, *E. coli*, *E. faecalis*, and *Pseudomonas* spp.

Recently, *A. baumannii* has been increasing as a cause of nosocomial infection. It has been detected in respiratory equipments, blood collecting equipments and beds, and causes of infection seem likely to be contact between medical workers and patients. *A. baumannii* induces septicemia, pneumonia, meningitis, urinary tract infection, peritonitis and dermatitis[14]. A National Nosocomial Infections Surveillance (NNIS) report announced in 1996 that 1% of infections and 4% of pneumonia cases in hospitals in the U.S.A were due to *Acinetobacter* spp from 1986 to 1996[15]. In addition, 2% of bloodstream infections and 6% of pneumonia cases at intensive care units (ICU) in the U.S.A were due to *Acinetobacter* spp from 1992 to 1997[16], and 9.7% of nosocomial infection was due to *Acinetobacter* spp in France.

A. baumannii can spread easily and persistently, and they can survive in dry environments and on dry surfaces. Moreover, it has multidrug resistance, and can be a cause of nosocomial infection[17–19]. In this study, *A. baumannii* was detected widely on the hand of physical therapists, treatment tables, pillows and floor of treatment rooms as well as on treatment equipments such as electrodes for transcutaneous nerve electrical stimulation (TENS), electrodes for interferential current therapy (ICT), electrodes for electrical stimulation therapy (EST), therapeutic baths, hot pack units, moist hot packs, ultrasound transducer heads, electrical hot packs, therapeutic balls, grips of pulleys, grips of shoulder wheels and grips of wrist rolls. Nosocomial infections in geriatric care hospitals treating the old with low level of immunity are increasing. Because patients are persistently exposed to therapists and various treatment equipment for a long time, physical therapists should adopt measures for infection control.

According to recent studies, *A. baumannii* have resistance to β-lactams, the extended spectrum cephalosporin, tobramycin, amikacin and fluoroquinolone[20–22]. Carbapenem antibiotics such as imipenem are useful treatments for Gram negative strains having resistance to β-lactams. However, some bacteria such as *A. baumannii, P.aeruginosa* and *Enterobacteriaceae* are resistant to imipenem, and antibiotic resistance has a serious problem because of antibiotics abuse[23,24]. In Korea, bacteria showing resistance to third and fourth generation cephalosporin, fluroquinolone, other β-lactams, piperacillin, aminoglycoside and cotrimoxazole are increasing year after year[25,26].

Because *A. baumannii* have multi-drug resistance frequency, it is difficult to treat[14]. In this study, we analyzed the antibiotic resistance pattern of *A. baumannii* which was the most isolated bacteria. They are resistant to ceftazidime (6.3%) which is a cephalosporin, ciprofloxacin (3.1%) which is a fluoroquinolone, imipemen (6.3%) which is commonly used as an effective drug, ampicillin (78.1%) and ampicillin/sulbactam (43.8%) which is combination of β-lactamase inhibitors.

We found no extended spectrum β-lactamase (ESBL) *E. coli* resistance to cefoxitin which is a third generation cephalosporin, nor did we find strain resistant to amikacin, gentamicin and fluoroquinolone, except ampicillin (16.7%). The frequency of the new resistance pathways to aminoglycoside, except streptomycin, by 16s rRNA methylase has been reported *E. cloacae* and *S. marcescens*[27]. In this study, *E. cloacae* and *S. marcescens* were not resistant to amikacin which is an aminoglycoside, but they were resistant to gentamicin (10%).

Coagulase-negative *Staphylococcus* (CNS) is a major pathogen of nosocomial infections and causes septicemia, especially in newborns and immunodeficient patients. Recently, methicillin-resistant CNS (MR-CNS) is increasing and is becoming one of the major causes of nosonomial infection[28]. In this study, all *Staphylococcus* spp were MR-CNS, but none were MRSA.

There is a high possibility of being infected by multi-drug resistant pathogens in physical therapy departments of geriatric care hospitals. Under Korean medical law, 1.5 infection controllers per 100 beds are required and one more infection controller is required whenever 250 beds are added to a hospital. However, there is no regulation of infection and health control in geriatric care hospitals. The Korean Nosocomial Infections Surveillance System (KONIS) is operated by university hospitals and ICUs. Korean geriatric care hospitals including small hospitals are located in a grey area. We should make an effort to eradicate nosocomial pathogens and multi-drug resistant bacteria by in traducing infection control systems, thoroughly controlling the health of patients and periodically sterilizing physical therapists and treatment equipments in geriatric care hospitals.

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