



Change of Antibiotic Resistance to the Causative Organisms of Pelvic Wound Infection for Recent 5 Years

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Purpose: We researched microbial profiles and the antimicrobial resistance profile of wound infection of the pelvic area in Korea for the recent 5 years in order to provide useful information on the choice of adequate drugs in the treatment of pelvic wound infection.

Materials and Methods: We retrospectively analyzed 211 pelvic wound culture samples and their antimicrobial resistance in 198 in- or out-patients of the Urology and Plastic surgery department from January 2010 to December 2014.

Results: Of the total samples, *Staphylococcus aureus* was isolated most frequently (35.3%), followed by *Escherichia coli* (15.1%), *Staphylococcus epidermidis* (12.6%), *Staphylococcus haemolyticus* (12.6%), *Staphylococcus lugdunensis* (8.4%), *Pseudomonas aeruginosa* (6.7%), *Enterococcus* spp. (4.2%), and *Streptococcus* spp. (3.3%). There were no notable changes of bacterial distribution for 5 years. For Gram-positive isolates, the oxacillin resistance rate for Gram-positive bacteria was 42.6% and showed an increasing tendency for the recent 5 years. Piperacillin, rifampicin, and vancomycin had low resistance for Gram-positive bacteria. Carbapenems, piperacillin/tazobactam had low resistance for Gram-negative bacteria. The Gram-positive organisms were more sensitive to many antibiotics in contrast to the Gram-negative organisms.

Conclusions: Of varied causative organisms and susceptibility of the pelvic wound site, the most frequently infected organisms of the pelvic area were *S. aureus*, followed by *E. coli*. The methicillin resistive *S. aureus* (MRSA) incidence showed a tendency to increase yearly, thus selection or early change of antibiotics considering MRSA is recommended if the antibiotic response is poor. Gram-negative bacteria has a higher resistance rate compared with Gram-positive bacteria and had carbapenems and piperacillin/tazobactam.

Keywords: Pelvic infection; Wound infection; Drug resistance; Methicillin

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INTRODUCTION

A wound is a disruption of normal anatomic structure and function of the skin, leading to breakdown of the protective function of the skin [1]. Wound healing is

influenced by multiple environmental and host factors. An infection in continuity constitutes wound infection. Wound infection is characterized by discharge in the lesion associated with signs of local inflammation such as pyrexia, pain and induration or systemic signs of sepsis. Any of

those factors can delay wound healing [2]. The most commonly acquired skin and soft tissue infections (SSTI) include cellulitis, folliculitis, furunculosis and trauma related wound infections. Many of which can be treated empirically with oral agents such as cephalosporins, β -lactamase stable penicillins or macrolides. Some infections particularly in patients with co-morbidities (e.g., diabetes mellitus, ischemic ulceration, chronic lymphoedema) or that have developed bacteremia, can be classified as complicated and often require hospitalization [3-6].

Although there were many previous studies about wound infections, most of the published data available focus on surgical site or burn wound infection. There is little data available on the specific microbial profile of the wounds presenting in Korea [7-13]. The epidemiology of the pathogens and their antibiotic resistance shows local and regional variation [14]. This study was thus designed to describe the microbial epidemiology and the antimicrobial resistance profile of wounds of the pelvic area in Korean. The data collected has been a guide to physicians on the antibiotics to be prescribed empirically.

MATERIALS AND METHODS

We retrospectively reviewed the clinical records of 198 patients who visited for wound infection (excluding post-operative wound infection) and conducted wound culture samples from Departments of Urology and Plastic Surgery of National Police Hospital from January 2010 to December 2014. Patients' medical records were obtained from the hospital information system and the data were analyzed with approval of National Police Hospital's Institutional Review Board (IRB No. 11100176-201509-HR-007).

Desired samples (pus/wound swab/tissue) were sent by the attending physician and were subsequently processed as per the standard protocols. The samples consisted of skin swabs, and transported in Amies Transport Medium

agar (Becton Dickinson, Basel, Switzerland) inoculated on sheep blood Columbia agar, MacConkey agar (Asan Inc., Hwaseong, Korea) and incubated aerobically for 2 days at 37°C with 5% CO₂. Bacterial isolates were identified according to standard methods by MicroScan WalkAway 96 SI system (Dade Behring Diagnostics, West Sacramento, CA, USA). Cultures were considered negative if no growth was observed after two days.

The data was analyzed by personal computer and SPSS ver. 13.0 software (SPSS Inc., Chicago, IL, USA).

RESULTS

Out of 198 patients, 170 patients with pelvic area wound infection visited for Department of Urology and 28 patients for Department of Plastic Surgery. Among the 198 patients, 211 wound culture samples were sent to the laboratory including 13 double samples. The mean age of the patients was 42.0±7.6 years (range, 2-90 years). Of these, 149 patients were male. The ratio of male to female was four to one. Organisms grew in 119 wound cultures (56.4%). Patients who identified in addition one pathogenic organism from wound culture samples were 43 patients over five years. There is no patient who identified more than three pathogenic organisms from samples. Moreover, the rate of samples which identified a single pathogenic organism was 87.5% in 2010 to 89.3% in 2014 (Table 1).

Gram-positive bacilli were the most commonly isolated

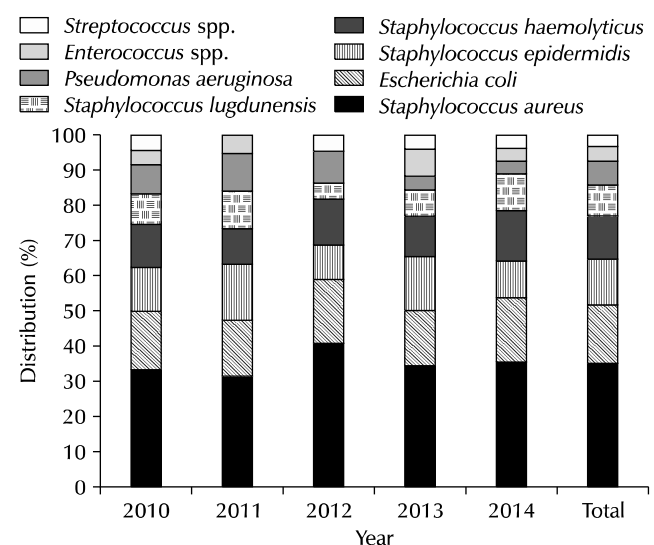


Fig. 1. Incidence of causative organisms of pelvic wound infection for 5 years.

Table 1. Distribution of mixed wound infection

Year	1 Organism	2 Organisms	Total
2010	21 (87.5)	3 (12.5)	24
2011	17 (89.5)	2 (10.5)	19
2012	20 (90.9)	2 (9.1)	22
2013	23 (88.5)	3 (11.5)	26
2014	25 (89.3)	3 (10.7)	28
Total	106	13	119

Values are presented as number (%) or number only.

Table 2. Changes of antibiotics resistance for gram-positive organisms

Organism	Year	Drug resistance (%)																
		OX	AM	AX/C	AN	CFZ	CFT	CTX	CFP	CIP	CC	IPM	EM	PIP	SXT	TC	RA	VCM
<i>Staphylococcus aureus</i>	2010	13.3	32.1	75.4	11.2	69.5	45.8	38.4	22.3	32.7	11.6	32.5	12.2	0.0	25.1	0.0	0.0	0.0
	2011	26.6	21.6	78.9	0.0	100.0	43.7	37.6	26.6	37.4	11.7	33.7	22.5	0.0	12.5	11.1	-	-
	2012	50.0	24.3	85.6	14.2	75.3	45.2	40.2	25.8	35.6	13.3	36.7	21.4	0.0	0.0	0.0	-	-
	2013	53.2	21.1	87.3	11.1	63.4	46.4	40.1	27.2	35.1	12.9	38.2	31.1	0.0	0.0	0.0	-	0.0
	2014	62.8	32.0	91.3	12.7	62.7	50.4	42.0	27.3	38.5	13.8	39.5	24.7	0.0	0.0	0.0	0.0	0.0
	Total	45.2	26.8	84.6	12.1	65.3	47.2	39.9	26.5	36.7	12.7	37.4	23.9	0.0	10.6	2.2	0.0	0.0
<i>Staphylococcus epidermidis</i>	2010	76.2	25.2	57.4	14.2	73.2	31.4	28.2	24.2	35.6	13.3	11.2	21.4	0.0	0.0	-	0.0	0.0
	2011	100.0	27.2	60.1	11.1	100.0	55.6	45.1	36.7	35.1	12.5	0.0	31.1	0.0	0.0	-	-	-
	2012	50.0	26.0	71.8	12.7	50.0	44.8	36.0	24.3	38.5	13.8	-	24.7	0.0	0.0	-	-	-
	2013	0.0	26.9	62.6	12.1	26.3	21.7	22.9	25.5	36.7	12.7	18.3	23.9	0.0	5.6	-	-	0.0
	2014	33.3	30.7	52.8	11.2	27.9	26.2	26.2	25.6	32.7	12.6	21.4	12.2	0.0	10.1	-	0.0	0.0
	Total	74.6	28.1	58.1	11.4	48.3	39.8	37.6	24.6	37.4	11.7	10.7	22.5	0.0	3.5	-	0.0	0.0
<i>Staphylococcus haemolyticus</i>	2010	50.0	16.1	36.7	21.4	25.3	0.0	27.1	12.3	35.1	11.1	39.7	0.0	0.0	-	-	-	0.0
	2011	-	11.1	38.2	31.1	26.2	0.0	26.3	12.1	39.3	-	-	0.0	0.0	-	-	-	-
	2012	54.1	15.6	39.5	24.7	26.4	0.0	26.6	16.5	38.4	-	-	14.1	0.0	-	-	-	-
	2013	50.0	21.2	37.4	23.9	27.1	5.6	26.5	15.9	39.7	0.0	12.7	0.0	0.0	-	-	-	0.0
	2014	50.0	17.3	12.7	11.2	27.3	12.7	27.5	14.7	38.7	-	-	0.0	12.7	-	-	0.0	0.0
	Total	52.1	18.4	30.2	24.6	26.5	2.5	26.8	15.2	38.6	2.6	1.5	2.4	2.5	-	-	0.0	0.0
<i>Staphylococcus lugdunensis</i>	2010	0.0	21.3	22.3	0.0	18.3	21.8	-	32.3	37.2	35.3	28.2	0.0	0.0	-	-	0.0	0.0
	2011	50.0	27.0	20.1	0.0	25.2	23.2	-	33.2	38.4	33.0	26.4	0.0	-	-	-	-	-
	2012	100.0	31.7	19.8	0.0	27.4	21.6	0.0	31.4	34.6	26.7	21.1	0.0	-	-	-	-	-
	2013	50.0	35.2	19.2	0.0	26.5	24.3	0.0	36.7	32.1	24.8	23.7	0.0	0.0	-	-	-	0.0
	2014	0.0	32.8	18.8	12.7	32.7	22.9	12.7	38.4	31.1	32.4	24.9	-	-	-	-	0.0	0.0
	Total	30.0	32.2	19.6	2.5	28.4	22.9	2.5	34.1	33.8	32.5	24.8	2.5	0.0	-	-	0.0	0.0
<i>Streptococcus spp.</i>	2010	-	11.2	11.2	11.2	11.2	22.8	11.2	22.3	32.7	11.6	32.5	12.2	0.0	25.1	11.1	0.0	0.0
	2011	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2012	-	11.4	0.0	10.0	-	22.4	22.4	23.4	36.7	12.5	28.4	15.3	0.0	24.6	0.0	-	-
	2013	-	0.0	12.3	11.4	32.5	31.8	21.4	22.5	38.1	11.4	34.1	15.2	0.0	24.2	0.0	-	-
	2014	-	0.0	11.4	10.2	22.3	30.8	26.7	21.8	35.6	12.7	29.4	16.1	0.0	25.4	11.1	0.0	0.0
	Total	-	3.4	7.8	8.4	26.4	27.7	21.5	21.1	36.3	11.4	28.5	15.0	0.0	24.3	5.8	0.0	0.0
<i>Enterococcus spp.</i>	2010	-	9.7	15.2	22.3	53.1	42.4	26.2	19.4	46.7	0.0	34.2	42.5	-	21.3	0.0	0.0	0.0
	2011	-	4.3	16.7	25.8	53.0	39.1	25.1	19.8	76.8	-	40.1	43.6	-	22.7	0.0	-	-
	2012	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2013	-	0.0	11.2	22.3	52.6	38.2	27.3	21.2	56.9	0.0	42.2	43.7	0.0	22.8	0.0	-	0.0
	2014	-	13.3	13.4	41.2	57.4	42.3	29.7	24.7	75.2	0.0	32.8	48.9	0.0	24.1	0.0	9.2	0.0
	Total	-	7.1	12.3	36.2	54.1	40.3	25.9	23.1	68.1	0.0	37.2	45.9	0.0	23.0	0.0	3.1	0.0
Total	2010	21.3	19.0	50.6	31.6	52.2	33.2	43.2	32.1	33.9	34.1	43.2	36.5	0.0	22.1	4.6	0.0	0.0
	2011	70.7	18.6	51.2	38.3	46.2	39.7	43.1	43.5	35.1	35.6	42.3	33.8	0.0	23.7	4.8	-	-
	2012	22.4	18.0	51.1	27.4	48.3	56.4	43.5	34.1	38.9	35.9	40.7	32.4	0.0	19.2	0.0	-	-
	2013	32.1	17.9	52.6	41.2	47.6	48.3	45.6	24.7	40.3	38.2	40.8	33.6	0.0	21.3	0.0	-	0.0
	2014	35.6	16.0	53.8	26.9	44.4	41.1	46.1	37.8	41.1	41.4	38.4	30.2	12.7	20.5	4.4	9.2	0.0
	Total	42.6	17.3	52.5	32.3	46.8	45.1	44.4	35.1	37.8	38.2	41.1	34.3	2.5	22.7	2.6	3.1	0.0

OX: oxacillin, AM: ampicillin, AX/C: amoxicillin/clavulanic acid, AN: amikacin, CFZ: cefazolin, CFT: cefotetan, CTX: ceftriaxone, CFP: cefepime, CIP: ciprofloxacin, CC: clindamycin, IPM: imipenem, EM: erythromycin, PIP: piperacillin, SXT: trimethoprim/sulfamethoxazole, TC: tetracycline, RA: rifampicin, VCM: vancomycin.

pathogens (78.2%). Only 21.8% of total isolates were Gram-negative bacteria. Of the total samples, *Staphylococcus aureus* was isolated most frequently (35.3%), followed by *Escherichia coli* (15.1%), *Staphylococcus epidermidis* (12.6%), *Staphylococcus haemolyticus* (12.6%), *Staphylococcus lugdunensis* (8.4%), *Pseudomonas aeruginosa* (6.7%), *Enterococcus spp.* (4.2%), and *Streptococcus spp.* (3.3%). There was no notable change of bacterial distribution for five years (Fig. 1). The antibiotic resistance data for Gram-positive bacteria are presented in Table 2. The oxacillin resistance rate for Gram-positive bacteria was

42.6% and had increasing tendency for recent five years, except in 2011. The ampicillin resistance rate for Gram-positive bacteria averaged 17.3% and slightly decreased between 2010 to 2014. Amoxicillin/clavulanic acid had the highest resistance rate (52.5%) out of all antibiotics for Gram-positive bacteria. The resistance rate was gradually increased for five years. In respect to the Gram-positive bacteria, the resistance rate of 1st, 2nd, 3rd, and 4th generation cephalosporins averaged as such: cefazolin, cefotetan, ceftriaxone, cefepime (46.8%, 45.1%, 44.4%, 35.1%). Subsequently, there was no increasing or

Table 3. Changes of antibiotics resistance for gram-negative organisms

Organism	Year	Drug resistance (%)															
		AM	AZT	AN	CFZ	CFT	CTX	CFP	CIP	IPM	MPM	GM	PIP/T	SXT	TiC/K	RA	VCM
<i>Escherichia coli</i>	2010	80.1	21.3	33.2	75.3	45.2	30.2	25.8	35.6	13.3	36.7	21.4	0.0	55.6	-	-	-
	2011	81.2	31.6	34.1	63.4	46.4	30.1	27.2	35.1	12.9	38.2	31.1	0.0	41.3	-	-	-
	2012	82.1	20.2	33.7	62.7	50.4	32.0	27.3	38.5	13.8	39.5	24.7	0.0	56.7	-	-	-
	2013	82.0	29.8	36.1	65.3	47.2	29.9	26.5	36.7	12.7	37.4	23.9	0.0	58.2	-	-	-
	2014	82.4	23.6	48.2	69.5	45.8	28.4	22.3	32.7	11.6	32.5	12.2	0.0	51.4	-	-	-
	Total	81.5	27.2	36.7	71.3	43.7	27.6	26.6	37.4	11.7	33.7	22.5	0.0	53.4	-	-	-
<i>Pseudomonas aeruginosa</i>	2010	73.3	16.7	62.7	38.4	34.2	21.1	16.1	55.1	16.1	0.0	0.0	0.0	51.7	-	-	-
	2011	72.9	18.2	71.4	44.4	31.6	17.4	15.3	52.3	17.3	-	0.0	0.0	49.8	-	-	-
	2012	73.8	19.5	68.7	46.8	41.7	16.2	10.2	61.3	18.6	-	14.1	0.0	55.8	-	-	-
	2013	75.7	17.4	63.9	40.5	37.8	16.0	11.6	50.2	5.3	0.0	0.0	8.7	54.9	-	-	-
	2014	80.0	22.7	-	0.0	37.3	15.4	15.3	54.3	25.8	-	0.0	0.0	59.2	-	-	-
	Total	75.6	20.5	65.7	43.4	36.4	16.3	13.4	54.0	22.1	0.0	2.4	1.8	55.4	-	-	-
Total	2010	72.8	29.1	42.2	65.2	38.2	18.0	20.1	45.2	6.3	5.0	44.4	0.0	56.3	-	-	-
	2011	74.0	25.4	43.1	58.3	38.6	19.1	22.4	46.1	9.1	5.2	42.7	0.0	54.1	-	-	-
	2012	76.2	23.7	48.7	59.4	41.3	21.3	25.3	45.1	6.9	4.9	43.7	0.0	56.5	-	-	-
	2013	77.9	19.6	46.8	54.9	42.6	22.1	25.1	43.8	4.6	4.8	46.1	8.7	56.8	-	-	-
	2014	81.1	26.7	49.6	56.4	42.5	22.2	19.1	44.2	7.5	6.1	43.9	0.0	55.1	-	-	-
	Total	77.4	24.9	48.9	57.5	40.7	22.8	22.6	44.6	6.8	5.3	44.3	1.8	54.1	-	-	-

AM: ampicillin, AZT: aztreonam, AN: amikacin, CFZ: cefazolin, CFT: cefotetan, CTX: ceftriaxone, CFP: cefepime, CIP: ciprofloxacin, IPM: imipenem, MPM: meropenem, GM: gentamicin, PIP/T: piperacillin/tazobactam, SXT: trimethoprim/sulfamethoxazole, TiC/K: ticarcillin/K clavulanic acid, RA: rifampicin, VCM: vancomycin.

decreasing tendency during five years. Ciprofloxacin, one of the fluoroquinolones, showed moderate resistance rate (37.8%) and had tendency to increase resistance rate. Trimethoprim/sulfamethoxazole (TMP/SMX) showed relatively low resistance rate (22.7%). Piperacillin, rifampicin and vancomycin had the lowest resistance for Gram-positive bacteria.

Resistance of *S. aureus*, that was most frequently identified, to some broad-spectrum, has gradually increased resistance to some drugs, but others such as have retained high levels of efficiency. Amoxicillin/clavulanic acid, cefazolin, cefotetan had high resistance rate to *S. aureus* (84.6%, 65.3%, 47.2%, respectively) and amikacin, clindamycin, piperacillin, TMP/SMX, tetracyclin, rifampicin, vancomycin had low resistance rate (12.1%, 12.7%, 0%, 10.6%, 2.2%, 0%, 0%, respectively).

S. epidermidis, *S. haemolyticus*, and *S. lugdunensis* showed similar drug resistance as well as resistance for cephalosporins and ciprofloxacin. *Streptococcus* has a relatively low resistance rate to many antibiotics, including *Enterococcus* spp. in which was drug resistance for recent five years.

The antibiotic resistance data for Gram-negative bacteria are presented in Table 3. The ampicillin resistance rate for Gram-negative bacteria was much higher (77.4%) than that of Gram-positive bacteria (17.5%). First generation

cephalosporins, aminoglycosides, quinolone, TMP/SMX had a high resistance rate for Gram-negative bacteria, but there were no significant changes during recent five years.

E. coli, the most frequently identified Gram-negative bacteria has high resistance to ampicillin, cefazolin, TMP/SMX (81.5%, 71.3%, 53.4%, respectively). Aztreonam, piperacillin/tazobactam, and imipenem has good susceptibility to *E. coli*.

P. aeruginosa has resistance to clinically, commonly used antibiotics, whereas aztreonam and imipenem, meropenem and piperacillin/tazobactam had relatively susceptibility for that organism.

DISCUSSION

Wound healing, characterized by wound remodeling and re-epithelialization, is halted in the presence of prolonged inflammation. Infection is the most common cause of prolonged wound inflammation [15]. Open wounds frequently get contaminated with skin flora. However, as the host defense weakens, bacteria tend to colonize and eventually may spread deeper in the tissues leading to wound infection characterized by erythema, induration and purulent discharge [16]. Many times the clinical symptoms are misleading, for instance pain may be absent in neuropathic ulcers. Absence of appropriate signs to guide

Table 4. Surgical site and likely infective wound pathogens

Surgical site	<i>Staphylococcus aureus</i>	Coagulase-negative <i>Staphylococci</i>	Gram-negative bacilli	<i>Streptococci</i>	Anaerobes	Other
Cardiac	✓	✓	-	-	-	-
Neurosurgery	✓	✓	-	-	-	-
Breast	✓	✓	-	-	-	-
Ophthalmic	✓	✓	✓	✓	-	-
Orthopaedic	✓	✓	✓	-	-	-
Vascular	✓	✓	-	-	-	-
Gastroduodenal	-	-	✓	✓	-	Oropharyngeal anaerobes
Biliary	-	-	✓	-	✓	-
Colorectal	-	-	✓	-	✓	-
Head and neck	✓	-	-	✓	-	Oropharyngeal anaerobes
Obstetric and gynaecological	-	-	✓	-	✓	<i>Enterococci</i> , group B <i>Streptococci</i>
Urological foreign material	✓	✓	✓	-	-	-

treatment becomes a reason for prolonged indiscriminate use of antibiotics which in turn leads to the rapid emergence of resistant organisms [17]. Thus, it is important to identify the microbiological epidemiology of the wounds presented in regional area and to know the susceptibility to the various antibiotics prescribed.

The nature of the causative organisms differs to the wound site, Phillips et al. [18] reported frequently infective pathogens with surgical sites (Table 4). In this study, *S. aureus* was isolated most frequently (29.2%), followed by *E. coli* (14.3%), *S. epidermidis* (12.2%), *S. haemolyticus* (12.2%), *S. lugdunensis* (10.3%), *P. aeruginosa* (7.7%), *Enterococcus* spp. (6.9%), and *Streptococcus* spp. (5.8%) from wound culture. This result is different with urinary tract infection microbial profiles. Kim et al. [19] reported and identified urinary tract infection organisms *Enterococcus* (19.4%), *Pseudomonas* (10.5%), *Staphylococcus* (8.0%), *Klebsiella* (6.7%), *Acinetobacter* (5.5%), *Enterobacter* (4.3%), *Proteus* (2.3%), *Citrobacter* (1.6%), *Streptococcus* (2.0%) from 1996 to 2005 in Korea. Hooton and Stamm [20] reported *E. coli* (75-90%), *Staphylococcus* (5-15%), *Enterococcus* and Gram-negative cocci (5-10%) for uncomplicated urinary tract infection.

And the regional variation of the pattern of wound infection pathogens are different. Jones et al. [21] and Kaul et al. [22] reported the five most common organisms were *S. aureus*, *Enterococcus* spp., *E. coli*, *P. aeruginosa*, and *Klebsiella* spp./*Proteus* spp. Those organisms were most typically found in infected wounds in Europe, United States, and Latin America [21-23]. The most common organism isolated in our study was *S. aureus* followed by *E. Coli*. Our findings were comparable to the findings of Wariso and Nwachukwu [17], whose most common isolate was

also *S. aureus*. Whereas in the study by Pondei et al. [14], *P. aeruginosa* was the most common pathogen, *Klebsiella pneumoniae* was observed to be the most common pathogen in wounds in a study in Western Nigeria [14]. However, Jones et al. [21] insisted that the most common organisms isolated in a broad setting of hospitalized community acquired infections. Not excluding nosocomial infections and susceptibility tested in participant clinical laboratories. Showing clearly the predominant role that of Gram-positive organisms, especially *S. aureus*, play in SSTI and *S. aureus* is the main causative agent of folliculitis, furuncles, carbuncles and cellulitis.

The Gram-positive organisms isolated in our study were more sensitive to many antibiotics in contrast to the Gram-negative pathogens, which were resistant to most of the commonly available antibiotics. Ampicillin is in the penicillin group of beta-lactam antibiotics and is able to penetrate Gram-positive and some Gram-negative bacteria. It is active against *Streptococcus*, *S. aureus* and resistance is relatively low in Korea, thus recommended to impetigo, erysipelas, cellulitis, necrotizing fasciitis [24]. In our study, the ampicillin resistance was 17.3%, its rate was similar to report of Gupta et al. [16].

The resistance of amoxicillin/clavulanic acid presented a high rate (52.5%) to Gram-positive bacteria. Especially *S. aureus* (84.6%), *S. epidermidis* (58.1%) showed high resistance rates. Those organisms had high resistance to oxacillin (45.2%, 74.6%, respectively). Amoxicillin/clavulanic acid is consisted of β -lactam antibiotic and β -lactamase inhibitor, and methicillin resistance of bacteria are conferred by encoding a penicillin binding protein with decreased affinity for β -lactam antibiotics. The resistance rate to amoxicillin/clavulanic acid of methicillin resistive *S. aureus*

(MRSA) and methicillin resistance coagulase-negative *Staphylococci* were nearly 100% in Europe/USA, Latin America [21-23]. However, in our study, it could not be explained why *S. epidermidis*, that has higher oxacillin resistance rate, and lower amoxicillin/clavulanic acid resistance rate than *S. aureus*. The reason could be due to an antibiotics abuse or statistical error from small size of population of this study.

Cephalosporins has resistances throughout all generations, showing different result with data of Europe and USA [21] (0-100%), but similar with data of India [25] (42.1%). The reason which data differs between Europe/USA and Korea/India is presumed that Europe/USA data was stated after methicillin sensitive *S. aureus* and MRSA were separated. The resistance rate of *S. aureus* to oxacillin (methicillin) was 45.2%.

Ciprofloxacin has 50.0% resistance rate and it was similar with India (47.4%) and Europe/USA varied per country (4.5-92.6%). Ciprofloxacin resistance is recently increasing corresponding with other previous studies in Korea, that is assumed overuse of quinolone [10-13]. TMP/SMX showed relatively low resistance rate (22.7%), and piperacillin, rifampicin, and vancomycin had the lowest resistance for Gram-positive bacteria (2.5%, 4.2%, 0.0%, respectively).

Staphylococcus spp. are likely contaminants and not likely causative agents of disease. However, in many cases, these organisms can cause secondary infections. That is if more pathogenic species colonize, systemic infection can occur [3,5]. *S. aureus*, the most isolated out of Gram-positive bacteria, as described above, is the most common pathogen in wound infection in many counties. *S. aureus* is a predominant pathogen in folliculitis, furuncles, carbuncles and cellulitis. In this study, *S. aureus* had a high resistance rate to oxacillin, amoxicillin/clavulanic acid, 1st and 2nd generation cephalosporin. Third, fourth generation cephalosporin and quinolone, imipenem had moderate resistance rate of 39.9%, 26.5%, 36.7, 37.4%, respectively. The cause of high resistance rate of *S. aureus* to those antibiotics is assumed that MRSA isolates comprise near a half portion (45.2%) of total *S. aureus* isolates. The oxacillin resistance rate of *S. aureus*, *S. epidermidis*, *S. haemolyticus*, and *S. lugdunensis* were 45.2%, 74.6%, 52.1%, 30.0%, respectively, and those isolates tended to have similar aspect of resistance rate to cephalosporins and ciprofloxacin. The prevalence of MRSA among SSTI isolated in each

geographical region is an important parameter to consider in choosing an empirical therapy, bearing in mind the involvement of *S. aureus* in this infection site. In the other studies, MRSA accounted for between 40% and 50% of *S. aureus* isolates in the USA and Italy, about 30-35% of isolates in France and Spain, approximately <15% of isolates in Germany [21], and 29.1% of isolates in India [25]. The MRSA incidence had tendency to increase yearly, so it is recommended to selection or early change of empirical antibiotics considering MRSA if the antibiotic response is poor.

In our study, *Streptococcus* and *Enterococcus* is susceptible to many antibiotics. *Enterococcus* spp., while comprising one of the most frequently isolated organisms from skin and wound sources in all countries, are unlikely to be the prime causative agent of infection in many cases. These organisms can often be involved in systemic infections with cutaneous lesions (such as endocarditis or bacteremia) or post-operative wound infections [26]. Additionally, this species should also be considered in immune-compromised patients colonized with these organisms. *Enterococcus* had low resistance rate to ampicillin, amoxicillin, piperacillin, rifampicin and vancomycin.

Gram-negative bacteria has higher resistance rate compared with Gram-positive bacteria. Whilst Gram-positive pathogens, especially *S. aureus* and *Streptococci* spp. associated with a range of virulence factors, are frequently the primary causative agents in SSTI. The role of *Enterobacteriaceae* is likely more opportunistic especially in hospitalized patients. *E. coli*, one of *Enterobacteriaceae*, was the most frequently cultured isolate from Gram-negative bacteria in our study, showing low resistance to imipenem, piperacillin/tazobactam, and relatively low resistance to aztreonam, ceftriaxone, gentamicin.

P. aeruginosa frequently cause post-operative wound infections [5,6,26]. Especially, *P. aeruginosa* is often implicated in folliculitis, myositis or other muscle pathologies, bites and burn wound infections [27]. Imipenem, meropenem and piperacillin/tazobactam had the lowest resistance rate.

One major limitation of the present study like many other studies was the absence of anaerobic cultures due to the lack of adequate resources. Additionally being a retrospective study, the type of wound and its detailed location of pelvic area (under umbilicus perineum) could

not be determined. Thus, no relationship between the type of wound and the microorganism isolated could be drawn. Moreover the change of resistance rate is unclear due to the small size of patient pool data. Also, the division of groups according to methicillin sensitive versus methicillin resistance will be helpful to a better analysis.

CONCLUSIONS

Wound infection is made up of a wide range of pathologies from superficial lesions to deep serious infections. It is potentially caused by a wide range of both Gram-positive and Gram-negative bacterial pathogens. Antibiotic resistance rate to causative organisms of pelvic wound infection are changing for recent years. The most frequently cultured organism in pelvic wound infection is *S. aureus*, and methicillin resistance rate tends to increase yearly. It is to be recommended to selection or early change of antibiotics, considering MRSA if the antibiotic response is poor. Gram-negative bacteria has a higher resistance rate compared with Gram-positive bacteria and had carbapenems and piperacillin/tazobactam.

Further surveillance data from local and national surveillance systems developing treatment guidelines may further help define the true impact of antimicrobial resistance on outcomes and clinical decision making.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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