Original Article

Prevalence and Antimicrobial Susceptibility of Bacteria Isolated from Surgical Site and Bloodstream Infections of Hospitalized Patients at a Tertiary Heart Center

Maryam Sotoudeh Anvari[1], Mohammad Ali Boroumand[1], Elham Amelimojarad[2], Marjaneh Nosrati[3], Neda Moradi[3], Hamidreza Goodarzynejad[2]

1. Dept. of Pathology, Tehran Heart Center, Tehran University of Medical Sciences, Tehran, Iran
2. Dept. of Research, Tehran Heart Center, Tehran University of Medical Sciences, Tehran, Iran
3. Dept. of Infection Control, Tehran Heart Center, Tehran University of Medical Sciences, Tehran, Iran

ABSTRACT

Background and Objectives: **Bacterial bloodstream infections (BSIs) and surgical site infections (SSIs) are among the most common nosocomial infections with high mortality and morbidity. We aimed to evaluate the frequency of various species among BSIs and SSIs at Tehran Heart Center, Tehran, Iran.**

Methods: **Patients with localized or systemic infections that became evident 48 hours or more after hospitalization were included. Data were prospectively collected in 4 intensive care units (ICUs), 5 cardiac care units (CCUs), 7 post-CCUs, and 5 surgical wards during two consecutive years in 2008 and 2009. Approximately 18414 coronary angiography and 7393 open-heart surgeries were done within this period. Antimicrobial susceptibility testing was performed by the Kirby–Bauer disk diffusion method, in accordance with the Clinical and Laboratory Standards Institute (CLSI) guidelines.**

Results: **Among 212 detected patients with SSI and/or BSI in the year 2008, 138 had hospital acquired infection (HAI) and 74 had non–HAI while these figures for 2009 was 165/270 and 105/270, respectively. *Staphylococcus aureus* (21.5%) and *Entrobacter* spp. (16.5%) were two most common pathogens responsible for hospital acquired BSIs while *S. aureus* (20.6%) and *S. epidermidis* (20.6%) were corresponding isolates responsible for community acquired BSIs. *Staphylococcus aureus* (53.3%) and *Escherichia coli* (11.0%) were the two most common pathogens responsible for hospital acquired SSIs in the year 2008, while *S. aureus* (49.0%) and *S. epidermidis* (11.0%) were the most frequently reported hospital acquired SSIs in 2009.**

Conclusions: **Making rational decisions about hospital infection control plans may reduce infection rates for bacteria with antimicrobial resistance.**

Keywords: **Prevalence, Nosocomial Infections, Surgical Wound Infection, Microbial Sensitivity Test**

Received: 26 September 2012
Accepted: 03 February 2013
Address communications to: Dr.Maryam Sotoudeh Anvari, Tehran Heart Center, Karegar Shomali st., Tehran, Iran.
E-mail: maryamsotoudeh2006@yahoo.com

Introduction

Bacterial bloodstream infections (BSIs) and surgical site infections (SSIs) are among the most common nosocomial infections and cause significant mortality, morbidity, and related socioeconomic costs worldwide (1-4). Nosocomial infections, also called "hospital-acquired infections (HAIs)", are defined as infections not presenting or not incubating when the patient is hospitalized which are acquired during the hospital stay at least 48-72 hours following admission to health institution. The estimated annual BSIs rate in the United States is approximately 350,000 patients with associated mortality rate of 20% to 50% (2, 5). The magnitude of SSI in different parts of the world varies considerably with a reported incidence of 0.25% to 2.9% and mortality rate ranging from 10% to 29% (6); however, SSIs are the most common cause of nosocomial infection (7) and are reported to be a serious complication following cardiac surgery (8, 9) increasing the relevant intensive care unit (ICU) admission up to 60%, hospital readmission more than five times, and the probability of death twice as compared to similar patients without SSIs (10).

Various types of antibiotics are available. Excessive and inappropriate use of antibiotics in health care facilities and in the communities will expedite the development of antibiotic resistance. To formulate a useful approach to the problem of inappropriate drug use providing data about antibiotic use pattern is crucial (11). In Iran, the prevalence of prevalent bacterial pathogens and their antimicrobial resistance patterns has not been established by a valid nationwide surveillance study so far, and only some localized data from individual hospitals have been reported. In addition, most of the previous investigations in this regard are point prevalence studies though the gold standard for such studies is prospective, on-site continuous, hospital wide surveillance (12).

Therefore, we aimed to conduct a prospective, on-site continuous, hospital wide study at Tehran Heart Center, a tertiary referral center, to evaluate the frequency of various species among surgical site and bloodstream infections. Our second purpose was to identify antimicrobial susceptibility pattern among the most prevalent isolates in order to provide a feasible guide for Iranian clinicians.

Materials and Methods

This study was conducted at Tehran Heart Center − a major referral and educational cardiac hospital affiliated to Tehran University of Medical Sciences. The center comprises four ICUs (86 beds), five cardiac care units (CCUs) (72 beds), seven post-CCUs (157 beds) and five surgical wards (120 beds). Data were collected prospectively for two consecutive years from 2008 to 2009. In the two years period, approximately 18414 coronary angiography and 7393 open-heart surgeries were performed in the hospital. All of our patients are routinely followed-up by our surgeons after the operation for one month if no implant is left in place and for one year if implant (prosthetic valves, nonhuman vascular grafts, mechanical heart, and implantable cardiovertor device) is in place. Patients with localized or systemic infections that became evident 48 hours or more after hospitalization were included in this study according to the Center for Disease Control and prevention (CDC, Atlanta, Ga., USA) definitions for HAI (13).

We investigated the two most common HAI types: SSIs, and BSIs. Detection of the infection was based on clinical findings as well as laboratory data and other tests according to a modified center of disease control and prevention (CDC)'s criteria (Table 1). Required data were collected from the HAI patients as described previously (7). Briefly, data gathered by on-site observation of the Infection Control Team, by using hospital information system (HIS), by using laboratory information system (LIS) reports, and also by using the hospital surgery database.

Table 1- Prevalent microorganisms isolated from blood cultures in total and in hospital acquired infections subgroup separately

Bacterial species or group	No. of isolates	Percent of isolates
Year 2008		
Hospital acquired		
Staphylococcus aureus	14	25.0
***Enterobacter* spp.**	10	17.9
***Enterococcus* spp.**	7	12.5
Staphylococcus epidermidis	6	10.7
Community acquired		
Staphylococcus aureus	16	23.2
Staphylococcus epidermidis	11	15.9
***Enterobacter* spp.**	10	14.5
***Klebsiella* spp.**	8	11.6
Year 2009		
Hospital acquired		
Staphylococcus aureus	12	18.5
***Enterobacter* spp.**	10	15.4
***Acinetobacter* spp.**	9	13.8
Pseudomonas aeruginosa	8	12.3
Community acquired		
Staphylococcus epidermidis	22	24.2
Staphylococcus aureus	17	18.7
***Acinetobacter* spp.**	10	11.0
Escherichia coli	7	7.7

Antimicrobial susceptibility testing was performed by the Kirby–Bauer disk diffusion method, in accordance with the Clinical and Laboratory Standards Institute (CLSI) guidelines (M02-A9). All culture samples referred to laboratory was qualified by quality control criteria and samples with colonization or contamination were excluded. Results are presented separately for each year of study (2008 and 2009) descriptively as raw numbers and percentages by the site of infection. For the statistical analysis, the statistical software SPSS version 13.0 for windows (SPSS Inc., Chicago, IL) was used.

Result

In the 2-year study period, 482 patients with SSI and/or BSI were detected with a mean age of 57 years. Among 212 detected patients with SSI and/or BSI in the year 2008, 138 (65.10%) had HAI and 74 (34.90%) had none–HAI while these figures for 2009 was 165/270 (61.11%) and 105/270 (38.89%), respectively.

Blood stream infections. Of 283 bacterial growth positive blood cultures, 126 (44.5%) occurred in 2008 and 157 (55.5%) in 2009. The proportion of HAI was 56 (44.4%) in 2008 as compared to 65 (41.4%) in 2009. Ward-wise distribution of bloodstream isolates at ICUs were 41.1% in the year 2008 and 53.8% in the next year. The majority of hospital acquired BSIs in the present study were caused by gram-positive organisms (31.4%). The four most common pathogens responsible for hospital acquired and community acquired infections subgroups are shown in Table 1.

In the study period, *S. aureus* (21.5%), *Entrobacter* spp. (16.5%), *Acinetobacter* spp. (13.8%) and *Pseudomonas aeruginosa* (12.3%) were the four most common pathogens responsible for hospital acquired BSIs while *S. aureus* (20.6%), *S. epidermidis* (20.6%), *E.* spp. (10.0%), *A.* spp. (7.5%) were corresponding isolates responsible for community acquired BSIs.

Antimicrobial susceptibility among species isolated from blood culture in patients with HAI is listed in Table 2. All *S. aureus* strains recovered from our blood cultures were susceptible to vancomycin; resistance to gentamicin, ciprofloxacin, and clindamycin was also relatively uncommon in HAIs − 25% (3/12), 25% (4/16) and 33.3% (7/21), respectively. A similar pattern of antimicrobial susceptibility was found among community acquired *S. aureus* infections. Methicilin Resistant *S. aureus* (MRSA) rate was 57.7% for HAIs and 42.2% for non-HAI infections. Ciprofloxacin 20/20 (100%) and meropenem (100%) and imipenem18/19 (94.7%) were the 3 most effective antibiotics among hospital acquired *Entrobacter* strains and 19/19 (100%) demonstrated resistance to cefalotin whereas community acquired *Entrobacter* isolates, demonstrated considerable susceptibility to most of the applied antibiotics (not shown in the table). Unfortunately, most of applied antibiotics did not show a desirable efficacy against *Acinetobacter* isolates in this study. The most effective antibiotic was imipenem 6/13 (46.2%) and ciprofloxacin 5/13 (38.5%) among hospital acquired strains while this pattern for infections acquired from community were 63.6% susceptibility to ciprofloxacin and 54.5% to imipenem.

Surgical site infections. Of 199 bacterial growth positive cultures cultivated from surgical site specimens, 86 (43.2%) occurred in 2008 and 113 (56.8%) in 2009. With regard to type of the infections, 95.3% of these isolates in the year 2008 were HAI in comparison with 88.5% in the year 2009. The distribution pattern of surgical site isolates at our hospital was 42.7% from ICU patients and 57.3% from non-ICU inpatients in the year 2008. In the following year, the corresponding proportions were 53 and 37 per cent. The majority of SSIs in the present study were caused by gram-positive organisms.

Staphylococci was the most prevalent group of organisms recovered from our surgical sites cultures in the study period (>50%). *Staphylococcus aureus* (53.3%) and *Escherichia coli* (11.0%) were the two most common pathogens responsible for hospital acquired SSIs in the year 2008, while *S. aureus* (49.0%) and *S. epidermidis* (11.0%) were the most frequently reported hospital acquired surgical site isolates in 2009 (Table 3).

Table 2- Antimicrobial susceptibility of species or groups isolated from blood cultures among hospital acquired infections in the study period

Microorganisms	Antimicrobial	Total No.	Susceptible	Intermediate	Resistant
Staphylococcus aureus		26			
	Ciprofloxacin	16	12 (75.0)	0	1 (6.3)
	Clindamycin	21	14 (66.7)	0	7 (33.3)
	Erythromycin	26	16 (61.5)	0	10 (38.5)
	Gentamicin	12	9 (75.0)	0	3 (25.0)
	Vancomycin	26	26 (100.0)	0	0
	Cefoxitin	26	11 (42.3)	0	15 (57.7) *MRSA*
Staphylococcus epidermidis		12			
	Clindamycin	9	2 (22.2)	1 (11.1)	6(66.7)
	Erythromycin	10	1 (10.0)	0	9 (90. 0)
	Gentamicin	7	6 (85.7)	0	1(14.33)
	Vancomycin	12	12 (100.0)	0	0
	Cefoxitin	12	2 (16.7)	0	10 (83.3)
	Ciprofloxacin	9	6 (66.7)	0	3 (33.3)
***Acinetobacter* spp.**		13			
	Amikacin	12	3 (25.0)	2 (16.7)	7 (58.3)
	Cefalothin	9	1 (11.1)	0	8 (88.9)
	Ciprofloxacin	13	5 (38.5)	0	8 (61.5)
	Ceftriaxone	13	2 (15.4)	0	11(84.6)
	Gentamicin	13	3 (23.1)	1 (7.7)	9 (69.2)
	Cefepime	13	2 (15.4)	0	11(84.6)
	ceftazidime	13	0	2 (15.4)	11(84.6)
	imipenem	13	6(46.2)	0	7(53.8)
	Meropenem	5	1(20.0)	0	4 (80.0)
	Ampicillin	9	0	0	9(100.0)
	Amoxicillin/ clavulanate	8	1(12.5)	0	7(87.5)
	Trimethoprim-sulfamethoxazole	11	3 (27.3)	0	8(72.7)
	tobramycin	6	1 (16.7)	1 (16.7)	4 (66.7)
***Enterobacter* spp.**		20			
	Cefalothin	19	0	0	19 (100.0)
	Ciprofloxacin	20	20 (100.0)	0	0
	Ceftriaxone	17	12 (70.6)	1 (5..9)	4 (23.5)
	Gentamicin	19	14 (73.7)	0	5 (26.3)
	ceftazidime	18	10 (55.6)	4 (22.2)	4 (22.2)
	Cefepime	19	12(63.2)	1 (5.3)	6 (31.6)
	imipenem	19	18 (94.7)	1 (5.3)	0
	Amikacin	20	16 (80.0)	2 (10.0)	2 (10.0)
	Meropenem	7	7(100.0)	0	0
	Amikacin	6	1 (16.7)	0	5 (83.3)
	Ciprofloxacin	7	2 (28.6)	1 (14.3)	4 (57.1)

Table 3- Prevalent microorganisms isolated from surgical site in total and in hospital acquired infections subgroup separately

Bacterial species or group	No. of isolates	Percent of isolates
Year 2008	82	
Hospital acquired		
Staphylococcus aureus	48	58.5
Escherichia coli	13	15.9
Staphylococcus epidermidis	7	8.5
Pseudomonas aeruginosa	4	4.9
Community acquired	4	
Staphylococcus aureus	1	25.0
Escherichia coli	1	25.0
Staphylococcus epidermidis	1	25.0
***Escherichia coli* inactive**	1	25.0
Year 2009		
Hospital acquired	100	
Staphylococcus aureus	49	49.0
Staphylococcus epidermidis	11	11.0
Escherichia coli	7	7.0
Pseudomonas aeruginosa	6	6.0
***Acinetobacter* spp.**	6	6.0
Community acquired	13	
Staphylococcus aureus	11	84.6
***Acinetobacter* spp.**	1	7.7
***Klebsiella* spp.**	1	7.7

Susceptibility rates of antimicrobial agents applied for the most prevalent isolated bacterial strains are summarized in Table 4. Regarding hospital acquired *S. aureus* strains, susceptibility to vancomycin was (100.0%) by performing minimum inhibitory concentration (MIC) method and followed by susceptibility to gentamycin (78.6), clindamycin (77.4%), ciprofloxacin (72.0%) and erythromycin (70.5%). The rate of MRSA among hospital acquired SSIs was 56.5% in the current study. The antimicrobial agents' response against community acquired *S. aureus* strains was quite different with 88.9% rate of MRSA was in this group of microorganisms.

Imipenem revealed 100.0% effectiveness against Escherichia coli isolates but more than 70% resistance was found with cefalothin, ciprofloxacin, ceftazidime, and ceftriaxone. Notably, susceptibility rate of vancomycin for *S. epidermidis* was near 100% while this microorganism revealed about 60% resistance to erythromycin. Furthermore the rate of MRSE was 64.3% among our hospital acquired SSIs. Other antimicrobial-resistant pathogens encountered among our patients include *P. aeruginosa* resistant to cefepime (4/10; 40%).

Table 4- Antimicrobial susceptibility of species or groups isolated from surgical site among hospital acquired infections in two years

Microorganisms	Antimicrobial	Total No.	Susceptible	Intermediate	Resistant
Staphylococcus aureus		*97*			
	Cefoxitin	85	37 (43.5)	0	48 (56.5) *MRSA*
	Ciprofloxacin	50	36 (72.0)	6 (12.0)	8 (16.0)
	Clindamycin	84	65 (77.4)	1 (1.2)	18 (21.4)
	Erythromycin	95	67 (70.5)	2 (2.1)	26 (27.4)
	Gentamicin	42	33 (78.6)	12 (2.4)	8 (19.0)
	Vancomycin	97	96 (99.0)	0	1 (1.0)
Escherichia coli		*20*			
	Amikacin	20	14 (70.0)	2 (10.0)	4 (20.0)
	Cefalothin	20	0	2 (10.0)	18 (90.0)
	Ciprofloxacin	20	3 (15.0)	0	17 (85.0)
	Ceftriaxone	19	3 (15.8)	1 (5.3)	15 (78.9)
	Gentamicin	20	11 (55.0)	0	9 (45.0)
	Cefepime	19	6 (31.6)	1 (5.3)	12 (63.2)
	Ceftazidime	20	4 (20.0)	0	16 (80.0)
	Imipenem	20	20 (100.0)	0	0
Staphylococcus epidermidis		*18*			
	Vancomycin	18	17 (94.4)	0	1 (5.6)
	Erythromycin	18	7(38.9)	2 (11.1)	9 (50.0)
	Cefoxitin	14	5 (35.7)	0	9 (64.3) *MRSE*
	Clindamycin	15	10 (66.7)	0	5 (33.3)
Pseudomonas aeruginosa		*10*			
	Amikacin	9	8 (88.9)	0	1 (11.1)
	Tobramycin	10	9 (90.0)	0	1 (10.0)
	Imipenem	10	8 (80.0)	1 (10.0)	1 (10.0)
	Ciprofloxacin	9	8 (88.9)	0	1 (11.1)
	Gentamicin	10	9 (90.0)	0	1 (10.0)
	Cefepime	10	3 (30.0)	3 (30.0)	4 (40.0)
	Ceftazidime	8	2 (25.0)	4 (50.0)	2 (25.0)

Discussion

A number of factors contribute to the emergence of antimicrobial resistance in various hospital wards including the severity of patient illness, predisposition to nosocomial infections, cross-transmission of pathogens characteristic of critical care areas within the hospital, compromised membrane and skin barriers following the use of invasive devices (14). These factors extend length of hospital stay, and the widespread use of prophylactic and therapeutic anti-infective agents. Surveillance of bacterial antimicrobial resistance is the most important challenges of our attempts to understand the dynamics of decreasing susceptibility to antibiotics in both hospital and community-acquired bacterial pathogens (15).

Since there are a few data regarding bacterial resistance pattern in Iran, it is essential to prospectively evaluate the distribution of bacterial species isolated and their susceptibility pattern (16). In the current study, *S. aureus* and *Entro-*

bacter spp. were the two most common hospital acquired blood culture isolates in our hospital laboratory in the study period. The majority of hospital acquired BSIs were caused by gram-positive organisms.

American and European investigations have generally demonstrated *S. aureus* and *E. coli* as the two most common hospital acquired blood culture isolates (15, 17, 18) while another study in United States introduced coagulase-negative staphylococci as the most prevalent organism responsible for BSI with the overall 78.1% frequency of gram-positive bacteria (19). In an Iranian children medical center, Coagulase-negative staphylococci and *S. aureus* were prevalent microorganisms isolated from blood cultures examined while 72% of isolations were gram-positive bacteria (16). Coagulase-negative *Staphylococci* accounted for most isolated bacteria (24.61%), in both genders. The second most frequent isolated bacteria in adults were *S. aureus*, and in children was *Klebsiella pneumonia* (20).

With regard to susceptibility of gram- positive organisms recovered from our blood cultures, we found all *S. aureus* isolates remained fully to be susceptible to vancomycin (100%), showing that isolates with reduced susceptibility still remain rare local events. This finding is compatible with the results of European SENTRY study, the surveillance program conducted in the USA, Canada and Latin America by the same network, and to the results from other regions of the world (15, 17, 18, 21).

Among *S. aureus* isolates, the incidence of resistance to methicillin was 57.7% in our study similar to that observed by the SENTRY study in the Asia-Pacific region (17). A report from another city in Iran has also documented similar rates of methicillin resistance (22). Across Europe, methicillin resistance in *S. aureus* averaged 24% but with considerable regional variation from less than 5% to more than 50 % (15, 18). *Enterobacter* species showed the lowest level of resistance to quinolones, meropenem and impanel which is in line with the findings of other local and international studies (16-18).

In the present investigation, coagulase-negative staphylococci and *E. coli* were the most common pathogens isolated from SSIs accounting for more than half of the cases of hospital acquired postoperative infections in the study period. *Staphylococcus aureus* is a major pathogen in mediastinitis which is associated with preoperative contamination (23, 24).

Among *S. aureus* isolated from SSIs in our study, the number of MRSA was 56.5% while the rate of methicillin resistance for *S. epidermidis* was 64.3%. These results suggest a better condition in our hospital than that of other hospitals in this geographic region (14, 25). Practicing good hand hygiene is the cornerstone of any infection prevention and control programs, which plays an essential role in reducing the transmission of organisms. Contact precautions, environmental, equipment cleaning, and decontamination present a great risk for contamination with MRSA (26).

All of the *S. aureus* and *Staphylococcus epidermidis* strains in our study had 100% susceptibility to vancomycin. This pattern is the same as findings of other Iranian studies (25, 27, 28).

Conclusion

Considerable differences in antimicrobial resistance do exist for each single hospital that reflects both antimicrobial usage pattern and infection control strategies. Making rational decisions about hospital infection control plans will reduce rates of infection with antimicrobial-resistant bacteria.

Acknowledgement

This study was financially supported by Tehran Heart Center, Tehran University of Medical Sciences. We would like to thank Pathobiology Laboratory personnel of our hospital for their kind cooperation. The authors declare that there is no conflict of interests.

References

1. Wenzel RP, Edmond MB. The impact of hospital-acquired bloodstream infections. Emerg Infect Dis 2001;7(2):174-7.

2. Diekema DJ, Beekmann SE, Chapin KC, Morel KA, Munson E, Doern GV. Epidemiology and outcome of nosocomial and community-onset bloodstream infection. J Clin Microbiol 2003;41(8):3655-60.

3. Bratzler DW. The Surgical Infection Prevention and Surgical Care Improvement Projects: promises and pitfalls. Am Surg 2006;72(11):1010-6; discussion 21-30, 133-48.

4. Poulakou G, Giamarellou H. Investigational treatments for postoperative surgical site infections. Expert Opin Investig Drugs 2007;16(2):137-55.

5. Mylotte JM, Tayara A. Blood cultures: clinical aspects and controversies. Eur J Clin Microbiol Infect Dis 2000;19(3):157-63.

6. Lepelletier D, Perron S, Bizouarn P, Caillon J, Drugeon H, Michaud JL, *et al*. Surgical-site infection after cardiac surgery: incidence, microbiology, and risk factors. Infect Control Hosp Epidemiol 2005;26(5):466-72.

7. Nosrati M, Boroumand M, Tahmasebi S, Sotoudeh M, Sheikhfathollahi M, Goodarzynejad H. Excess costs associated with common healthcare-associated infections in an Iranian cardiac surgical unit. J Hosp Infect 2010;76(4):304-7.

8. Martone WJ, Nichols RL. Recognition, prevention, surveillance, and management of surgical site infections: introduction to the problem and symposium overview. Clin Infect Dis 2001;33 Suppl 2:S67-8.

9. Bitkover CY, Gardlund B. Mediastinitis after cardiovascular operations: a case-control study of risk factors. Ann Thorac Surg 1998;65(1):36-40.

10. Kirkland KB, Briggs JP, Trivette SL, Wilkinson WE, Sexton DJ. The impact of surgical-site infections in the 1990s: attributable mortality, excess length of hospitalization, and extra costs. Infect Control Hosp Epidemiol 1999;20(11):725-30.

11. Woods RK, Dellinger EP. Current guidelines for antibiotic prophylaxis of surgical wounds. Am Fam Physician 1998;57(11):2731-40.

12. Pittet D, Harbarth S, Ruef C, Francioli P, Sudre P, Petignat C, *et al*. Prevalence and risk factors for nosocomial infections in four university hospitals in Switzerland. Infect Control Hosp Epidemiol 1999;20(1):37-42.

13. Olmsted RN. APIC infection Control and Applied Epidemiology: Principles and Practice. St. Louis:Mosby;1996.

14. Bayram A, Balci I. Patterns of antimicrobial resistance in a surgical intensive care unit of a university hospital in Turkey. BMC Infect Dis 2006;6:155.

15. Decousser JW, Pina P, Picot F, Delalande C, Pangon B, Courvalin P, *et al*. Frequency of isolation and antimicrobial susceptibility of bacterial pathogens isolated from patients with bloodstream infections: a French prospective national survey. J Antimicrob Chemother 2003;51(5):1213-22.

16. Mamishi S, Pourakbari B, Ashtiani MH, Hashemi FB. Frequency of isolation and antimicrobial susceptibility of bacteria isolated from bloodstream infections at Children’s Medical Center, Tehran, Iran, 1996-2000. Int J Antimicrob Agents 2005;26(5):373-9.

17. Diekema DJ, Pfaller MA, Jones RN, Doern GV, Kugler KC, Beach ML, *et al*. Trends in antimicrobial susceptibility of bacterial pathogens isolated from patients with bloodstream infections in the USA, Canada and Latin America. SENTRY Participants Group. Int J Antimicrob Agents 2000;13(4):257-71.

18. Fluit AC, Jones ME, Schmitz FJ, Acar J, Gupta R, Verhoef J. Antimicrobial susceptibility and frequency of occurrence of clinical blood isolates in Europe from the SENTRY antimicrobial surveillance program, 1997 and 1998. Clin Infect Dis 2000;30(3):454-60.

19. Karlowsky JA, Jones ME, Draghi DC, Thornsberry C, Sahm DF, Volturo GA. Prevalence and antimicrobial susceptibilities of bacteria isolated from blood cultures of hospitalized patients in the United States in 2002. Ann Clin Microbiol Antimicrob 2004;3:7.

20. Abdollahi A, Tabriz HM, Mahfoozi S. Frequency of pathogens and antimicrobial susceptibility of bacteria isolated from bloodstream infections. Iran J Pathol

2010;5:143-9.

21. Mehta M, Dutta P, Gupta V. Antimicrobial susceptibility pattern of blood isolates from a teaching hospital in north India. Jpn J Infect Dis 2005;58(3):174-6.

22. Japoni A, Ziyaeyan M, Jmalidoust M, Farshad S, Alborzi A, Rafaatpour N, *et al*. Antibacterial susceptibility patterns and cross-resistance of methicillin resistant and sensitive Staphyloccus aureus isolated from the hospitalized patients in Shiraz, Iran. Brazil J Microbiol 2010;41:567-73.

23. Jonkers D, Elenbaas T, Terporten P, Nieman F, Stobberingh E. Prevalence of 90-days postoperative wound infections after cardiac surgery. Eur J Cardiothorac Surg 2003;23(1):97-102.

24. Sharma M, Berriel-Cass D, Baran J Jr. Sternal surgical-site infection following coronary artery bypass graft: prevalence, microbiology, and complications during a 42-month period. Infect Control Hosp Epidemiol 2004;25(6):468-71.

25. Khorvash F, Mostafavizadeh K, Mobasherizadeh S, Behjati M, Naeini AE, Rostami S, *et al*. Antimicrobial susceptibility pattern of microorganisms involved in the pathogenesis of surgical site infection (SSI); A 1 year of surveillance. Pak J Biol Sci 2008;11(15):1940-4.

26. Jarvis WR, Schlosser J, Chinn RY, Tweeten S, Jackson M. National prevalence of methicillin-resistant Staphylococcus aureus in inpatients at US health care facilities, 2006. Am J Infect Control 2007;35(10):631-7.

27. Ghadiri H, Vaez H, Khosravi S, Soleymani E. The Antibiotic Resistance Profiles of Bacterial Strains Isolated from Patients with Hospital-Acquired Bloodstream and Urinary Tract Infections. Crit Care Res Pract 2012;2012:890797.

28. Soltani R, Khalili H, Abdollahi A, Rasoolinejad M, Dashti-Khavidaki S. Nosocomial Gram-positive antimicrobial susceptibility pattern at a referral teaching hospital in Tehran, Iran. Future Microbiol 2012;7:903-10.