Original Article

Evaluation of Bacterial Nosocomial Infections and Antibiotic Resistance Pattern: A 2-year Epidemiological Surveillance Study in a Hospital Population

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Abstract:

Introduction: Hospital infections and bacterial antibiotic resistance are numerous issues that have been reported worldwide over the years and lead to costly and long-term treatment options. The purpose of this study was to survey the prevalence of nosocomial bacterial infections and antibiotic resistance patterns of the bacteria in hospitalized patients admitted to a teaching hospital in the north of Iran.

Methods: This cross-sectional study performed by using available data and census methods on all patients with nosocomial infections (NIs) who were admitted to BO-ALI SINA hospital from March 2017 to March 2018. MS Excel 2016 and SPSS version 16.0 were used for statistical analysis.

Findings: Out of 517 patients with positive bacterial cultures, 57.3% were female. Escherichia coli, Staphylococcus epidermidis, and Klebsiella pneumonia were the most prevalent agents of NIs. The highest infection rate in hospital wards was observed in internal medicine, neurology, and intensive care units, respectively. E. coli showed the highest resistance rate against ampicillin (88.7%) and cephalexin (74.2%).

Conclusion: Early recognition of the infections with proper infection control procedures can significantly decrease the incidence of nosocomial infections in hospitals. Various studies have shown that antibiotic resistance patterns are different in dissimilar regions. Increasing the antibiotic resistance can be a sign of improper use of antibiotics, indicating the need for more attention to it. Our findings can help physicians and health care staff to have better treatment options against the bacterial NIs.

Keywords: Nosocomial Infection, Antibiotic Resistance, Hospital,Bacteria.

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Introduction:

Nosocomial infections (NIs) or hospital-acquired infections can be transmitted from the hospital environment or health care staff to patients admitted to hospitals or health care settings (1). NIs mostly occur 48 hours after admission in the hospital or 30 days after discharge from the hospital (2). Bacteria are the most important pathogens causing a wide range of nosocomial infections (3). Epidemiological studies conducted by WHO on five hospitals of fourteen countries in Europe, Eastern Mediterranean, South- East Asia, and Western Pacific (4 WHO regions) showed that at least 8.7% of the patients admitted to the hospitals had a nosocomial infection (4). Also, more than 1.4 million people over the world are complicated with nosocomial infection (5). Usually, after the emergence of infection symptoms, people start the use of antibiotics arbitrarily, while through the exchange of genetic resistance elements by the bacteria, the use of antibiotics can develop new multi-drug resistant strains (6). While sensitive bacteria killed by the antibiotics, resistant ones survive and can be endemic in the hospitals and become an issue for the remedy of patients and control of diseases (7, 8). Hospital infections and antibiotic resistance are numerous issues that have been reported worldwide over the years and lead to costly and long-term treatment options. Epidemiological studies showed that the risk of infectious diseases had been risen steadily (9). Bacterial agents such as Staphylococcus Spp., Enterobacteriaceae, Pseudomonas aeruginosa, and Escherichia coli are the most prevalent bacteria causing urinary tract infection (UTI) or pneumonia in the hospitals (9, 10). Gram-negative bacteria usually account for 70 to 90 percent of the urinary tract infections, from which Escherichia coli is the most prevalent one (11). Klebsiella pneumonia, Proteus mirabilis, Acinetobacter baumannii, and Serratia spp. are other Gram-negative bacteria in this issue. However, only 10% of the cases are caused by gram-positive bacteria such as enterococci, staphylococci, and streptococcus agalactiae (12). Bacterial meningitis (BM) is one of the most severe clinical infections with high mortality (13). Streptococcus pneumonia is the most common cause of BM incidence in hospitals (14). Acinetobacter baumannii, which is found in soil and water, accounts for 80% of the reported infections in Intensive Care Units (ICUs) of the teaching and treatment hospitals (15).

Moreover, Bacteroides fragilis is a gastrointestinal tract normal flora, which, in combination with other bacteria, can cause various infections (16). Also, Clostridium difficile origins colon inflammation leading to diarrhea associated with antibiotics mainly due to the removal of beneficial bacteria (17). In this study, we evaluated the prevalence of bacterial NIs and the antibiotic resistance pattern of the bacteria isolated from hospitalized patients in BO_ALI SINA teaching and treatment hospital in the north of Iran.

Methods:

Study design

This cross-sectional study performed by using available data and census methods on all patients with NIs who were admitted to BO-ALI SINA teaching and treatment hospital (affiliated to Mazandaran University of Medical Sciences, sari, Iran) in the period between March 2017 to March 2018.

Inclusion criteria included medical records of hospitalized patients who had the NIs symptoms stayed more than 48 h in the hospital. The exclusion criteria of the study were the patients with incomplete medical records, patients without bacterial NIs, non-prescribed patients for antibiotics, and patients with bacterial culture-negative results.

Data collection

Two members of our team referred to the laboratory to record data and medical documents of the hospital and complete the checklists for available information. The investigated demographic information included age, gender, type of infection, antibiotics prescribed for the patients, sample type, wards which patients were hospitalized, and laboratory results of antimicrobial susceptibility testing. All data were obtained from computerized records and manual archives of the hospital.

The nurse and laboratory technician did sampling in the different ward and then were transferred to the laboratory for identification of the organisms causing infection.

Antimicrobial susceptibility testing

Bacterial isolates were identified through culture, gram stain, microscopy, and biochemical standard tests (18). Blood agar, eosin methylene blue media (EMB), MacConkey agar (Merck Co., Germany), and chocolate agar were used for culture. An antibiotic susceptibility assay was performed by the disk agar diffusion method according to the criteria of the clinical and laboratory standards institute (19). The antibiotics included amikacin, gentamycin, ceftriaxone, imipenem, nalidixic acid, ampicillin, cephalexin, ceftazidime, vancomycin, and co-trimoxazole.

Data analysis

Data about the patients affected by nosocomial infections analyzed with statistical package for the social sciences 16.0 (SPSS Inc.) for some detailed statistical calculations.

Ethical consideration

The ethics committee of Mazandaran University of Medical Sciences has approved the present study by code 4871, which adopted on Jan 16, 2019. To comply with ethical standards, all information contained in the laboratory archives was used confidentially and exclusively for the aim of this study, and all files were delivered to the archives without any changes.

Findings:

Out of 517 patients with bacterial positive culture result, 221 (42.7%) of them were male. The average age of the patients was 45.77 ± 33.96 years (from 1-94-year-old). Most patients (35.4%) belonged to the age-group of under twenty-year-old. The most common isolated bacteria in all cultures were Escherichia coli (48.8%),

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Staphylococcus epidermidis (22.9%), and Klebsiella pneumonia (12%). The distribution of various microorganisms isolated from bacterial cultures has been shown in figure 1.

Among the all bacteria isolated from the clinical samples, E. coli showed the highest frequency as 49.8%, 45.5%, 49.1% and 54.2% in the age-groups of less than 20, 41-60, 61-80, and more than 81 years, respectively. However, in the age-group of 21-40 years, S. epidermidis was the most frequent pathogen (41.7%). Detailed information about the frequency of the isolated microorganisms in terms of gender and age-groups is show in table 1. The distribution of urinary tract, bloodstream and wound infections in terms of age-groups is also shown in table 2.

The highest rate of infections in the hospital wards (18.4%, 17.2% and 15.7%) were observed in internal medicine, neurology and intensive care units, respectively. Escherichia coli was the most commonly observed pathogen in most of the hospital wards, but Staphylococcus epidermidis was more frequent in the oncology, obstetric and ophthalmology units. The frequency of isolated organisms in terms of hospital wards is shown in table 3.

Out of 517 bacterial-culture-positive-samples, 420 (81.2%), 69 (13.3%), and 28 (5.5%) of them were related to urinary tract, bloodstream, and wound infections. The most common bacterial pathogen which observed in urinary tract cultures was E. coli (56.9%). Staphylococcus epidermidis was the most common organism isolated from bloodstream (26.1%) and wound infections (28.6%). Details about the prevalence of bacteria isolated from different samples are shown in the table 4.

Escherichia coli showed the highest resistance rate to ampicillin (88.7%) and cephalexin (74.2%). Staphylococcus epidermidis, Klebsiella pneumoniae, Staphylococcus aureus, and Acinetobacter baumannii exhibited the maximum antibiotic resistance rate against ampicillin (90.5%, 80%, 95.1%, 92.7%, and 75%), respectively. Also, 100% of the clinical isolates of Staphylococcus saprophyticus were resistant to cephalexin and co-trimoxazole. The highest sensitivity rate of Staphylococcus epidermidis clinical isolates was shown against amikacin (93.5%) and vancomycin (89.5%), while 93.1% of the Pseudomonas aeruginosa clinical isolates were susceptible to imipenem. The antibiotic susceptibility patterns of Gram-negative and Gram-positive isolated bacteria in this study are shown in table 5 and 6.

Discussion:

Hospital infections are one of the most public health problems creating concern worldwide. Despite advances in healthcare and antibiotic prophylaxis, nosocomial infections are persistent in many patients admitted to hospitals (20).

In this study, the most common isolated microorganisms were Escherichia coli (48.8%), Staphylococcus epidermidis (22.9%), Klebsiella pneumonia (12%), and Pseudomonas aeruginosa (8.3%). However, in the study of Davoudi et al. (20), P. aeruginosa and Acinetobacter baumannii were detected as the most common

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organisms, while other Iranian study conducted by bijari et al. (21) showed that K. pneumoniae, P. aeruginosa and E. coli were more prevalent than other bacteria. Interestingly, two same studies which carried out in six Persian Gulf Arab countries including Saudi Arabia, Qatar, Bahrain, Kuwait, Oman, and United Arab Emirates (21, 22), showed that E. coli, K. Pneumoniae, P. aeruginosa, Methicillin-Resistant Staphylococcus aureus (MRSA) and A. baumannii were the most common pathogen causing nosocomial infections in these countries neighbor of Iran. Nevertheless, in some developing countries such as Latin America and South Africa, A. baumannii and K. pneumoniae were the most common cause of healthcare-acquired infections (23).

The highest frequency of infection (183 out of 255) was observed in the age-group of less than 20-year-old and more than 61-year-old patients of the present study. This can be due to the people in these age-groups are more likely admitted to the hospitals because of their weakened body, poor hygiene, weak immune system, various underlying diseases, and long-time staying in the hospital for recovery. However, they are more susceptible to acquiring hospital infections. Also, the most common cause of infection in these age-groups was E. coli, which is the most prevalent cause of urinary tract infection. This finding in our study was comparable with the results of similar local studies conducted by Bijari et al. (21) and Larypoor et al. (24) in Iran.

Among different wards of the hospital, the highest infection rate was observed in the internal medicine (18.4 %), neurology (17.2%), and ICU (15.7%), respectively, while E. coli was the most frequent agent in all units. These results were similar to a study conducted by Mancini et al. (25), where the highest infection rate (41.3%) was reported in internal medicine. However, other studies carried out in Iran showed different results about this issue (20, 21, 26). This difference may be due to the relatively low numbers of patients in our ICUs compared with other studies.

Similar to other countries worldwide (27), we found that the most cause of urinary tract infection was E. coli, while 80% of the cases were related to the use of urological devices, especially urinary tract catheters (28). Moreover, S. epidermidis, K. pneumoniae, and E. coli were the most common microorganisms causing bloodstream infection, which was similar to the study of Davoudi et al. (20). In a study done in Northern Oman, it is reported that E.coli and K. pneumoniae are significant pathogens in bloodstream infections (29).

However, about wound infections, we found different results with the mentioned research. S. epidermidis was the most common bacterium (39.3%), causing wound infection in our study, while they reported that S. aureus was the most prevalent organism causing this infection (20). S. epidermidis is the normal flora of the skin, and our different result about wound infection may be due to the contamination of the samples, the lack of checking this positive result by staff, the poor disinfection of the laboratory devices or the

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inappropriate cleaning of patients' skin during the sampling.

As shown in Tables 5 and 6, the ampicillin, cephalexin, and co-trimoxazole were the top three least effective antibiotics in the present study, similarly, other studies conducted by Lavakhamseh et al. (30), and Keihanian et al. in Rasht, North of Iran (31). These similarities can be due to the same antibiotic prescription policy in Iran.

In a study that evaluated the microbiological profile of urinary tract infections in Mexico, the most antibiotic resistance rate was shown against ampicillin (32). This was comparable with another study conducted on uropathogenic (33), which showed that all gram-negative bacteria were resistant to this antibiotic. However, a Ten-year analysis of bacterial keratitis (34) showed the same result about the rate of ampicillin-resistant isolates. Also, African research in Ethiopia reported that ampicillin and co-trimoxazole were the least effective antibiotics in their region (35). Our study, similar to another Iranian research (31), showed the high efficiency of amikacin, vancomycin, imipenem, and gentamycin for the treatment of nosocomial infections in Iran.

However, the observations of Mun et al. showed the same results, as all their gram-positive bacteria were susceptible to vancomycin, and most of the gram-negative bacteria were susceptible to imipenem (34). Moreover, Woldemariam et al. indicated that amikacin has a significant effect on Gram-negative pathogens (33). The same situation was shown by Gorems et al. that the majority of bacterial isolates were susceptible to ciprofloxacin (72.9%), gentamicin (70.4%) and amikacin (69.3%) (35).

Conclusion:

The results of this study showed that permanent teeth may erupt earlier in obese children, which clarifies the need for periodic dental examinations in this group of children. Also, BMI correlates with permanent teeth eruption and dmft value, so that the more weight gain may be results in the more eruption of permanent teeth and lower dmft values.

Conclusion:

Nosocomial infections become a serious problem for the health care system all over the world. Information about a different aspect of NIs can help hospital staff and physicians to better infection control. Early recognition of infections with proper infection control procedures can significantly decrease the incidence of nosocomial infections in hospitals. Various studies have shown that antibiotic resistance patterns are different in dissimilar regions, and by knowing the best option for overcoming pathogens, we can interestingly reduce the prevalence of NIs. Increasing the antibiotic resistance can be a sign of improper use of antibiotics, indicating the need for more attention to it**.**

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Tables and Charts:

Table 1: The correlation between the frequency of isolated bacteria and gender and age-groups.

No. (%) of the isolated organisms		*Escherichia coli*	*Staphylococcus epidermidis*	*Klebsiella pneumoniae*	*Pseudomonas aeruginosa*	*Staphylococcus saprophyticus*	*Staphylococcus aureus*	*Acinetobacter baumannii*	*Streptococcus pneumonia*	*Streptococcus viridans*	*Proteus mirabilis*	*Salmonella Spp.*	*Enterococcus Spp.*	*Streptococcus pyogenes*	**Total**
gender	**Male**	95 (43)	52 (23.5)	28 (12.7)	19 (8.6)	13 (5.9)	6 (2.7)	3 (1.4)	3 (1.4)	-	-	1 (0.5)	-	1 (0.5)	221 (100)
	Female	156 (52.7)	67 (22.6)	33 (11.1)	22 (7.4)	7 (2.4)	2 (0.7)	3 (1)	1 (0.3)	2 (0.7)	2 (0.7)	-	1 (0.3)	-	296 (100)
Age-groups (years)	**≤20**	91 (49.8)	40 (21.9)	18 (9.8)	13 (7.1)	11 (6.1)	1 (0.5)	5 (2.7)	1 (0.5)	2 (1.1)	-	-	-	1 (0.5)	183 (100)
	21-40	5 (20.7)	10 (41.7)	3 (12.5)	2 (8.3)	1 (4.2)	1 (4.2)	-	1 (4.2)	-	-	-	1 (4.2)	-	24 (100)

	41-60	25 (45.5)	15 (27.3)	5 (9.1)	7 (12.7)	1 (1.8)	1 (1.8)	-	1 (1.8)	-	-	-	-	-	55 (100)
	61-80	79 (49.1)	39 (24.2)	15 (9.3)	13 (8.1)	6 (3.8)	4 (2.5)	1 (0.6)	1 (0.6)	-	2 (1.2)	1 (0.6)	-	-	161 (100)
	≥81	51 (54.2)	15 (15.9)	20 (21.3)	6 (6.4)	1 (1.1)	1 (1.1)	-	-	-	-	-	-	-	94 (100)

Table 2: The distribution of urinary tract, bloodstream and wound infections in terms of age-groups.

Type of infections / **Age-groups**	**Urinary tract infection No. (%)**	**Bloodstream infection No. (%)**	**Wound infection No. (%)**	**Total**
≤20	118 (22.8)	43 (8.3)	22 (4.3)	183 (35.4)
21-40	20 (3.9)	3 (0.6)	1 (0.2)	24 (4.6)
41-60	51 (9.9)	2 (0.4)	2 (0.4)	55 (10.6)
61-80	144 (27.9)	16 (3.1)	1 (0.2)	161 (31.1)
≥81	87 (16.8)	5 (1)	2 (0.4)	94 (18.2)
Total	420 (81.2)	69 (13.3)	28 (5.5)	517 (100)

Table 3: The frequency of isolated bacteria in terms of hospital wards.

No. of isolated organisms	***Escherichia coli***	***Staphylococcus epidermidis***	***Klebsiella pneumoniae***	***Pseudomonas aeruginosa***	***Staphylococcus saprophyticus***	***Staphylococcus* aureus**	***Acinetobacter baumannii***	***Streptococcus pneumonia***	***Streptococcus viridans***	***Proteus mirabilis***	***Salmonella Spp.***	***Enterococcus Spp.***	***Streptococcus* pyogenes**	**Total**
Internal medicine	54	26	8	3	1	1	0	2	0	0	0	0	0	95
Neurology	43	16	10	13	4	3	0	0	0	0	0	0	0	89
ICU	31	13	20	10	3	1	1	2	0	0	0	0	0	81

Emergency	36	18	5	3	1	1	0	0	0	0	1	1	0	66
Pediatric infectious	30	7	2	4	3	1	0	0	0	0	0	0	0	44
Pediatric surgery	19	7	1	2	3	1	0	0	0	0	0	0	1	34
NICU	6	5	6	2	1	0	4	0	0	0	0	0	0	24
Pediatrics	13	5	1	1	1	0	0	0	1		0	0		22
Neonates	7	6	2	1	2	0	1	0	0	0	0	0	0	19
PICI	5	0	3	0	0	0	0	0	0	0	0	0	0	13
Oncology	2	6	2	0	1	0	0	0	1	0	0	0	0	12
Obstetrics	3	6	0	0	0	0	0	0	0	1	0	0	0	10
ENT	2	2	0	0	0	0	0	0	0	1	0	0	0	5
ophthalmology	0	2	1	0	0	0	0	0	0	0	0	0	0	3
Total	251	119	61	41	20	8	6	4	2	2	1	1	1	517

Abbreviations: ICU, Intensive Care Unit; NICU, New-born Intensive Care Unit; PICU, Post Intensive Care Unit; ENT, Ear, Nose & Throat.

Table 4: The frequency of bacteria isolated from urinary tract, bloodstream and wound infections.

Bacteria	**Type of infections No. (%)**		
	Urinary tract infection	**Bloodstream infection**	**Wound infection**
Escherichia coli	239 (56.9%)	7 (10.1%)	5 (17.9%)
Staphylococcus epidermidis	93 (22.1%)	25(36.2%)	11(39.3%)
Klebsiella pneumoniae	42 (10%)	15 (21.7%)	4 (14.3%)
Pseudomonas aeruginosa	31 (7.4%)	9 (13.1%)	1 (3.6%)
Staphylococcus Saprophyticus	6 (1.4%)	2 (2.9%)	2 (7.1%)
Staphylococcus aureus	6 (1.4%)	-	3 (10.7%)
Acinetobacter baumannii	-	4 (5.8%)	2 (7.1%)
Streptococcus pneumoniae	-	3 (4.3%)	-
Streptococcus viridans	-	2 (2.9%)	-
Proteus mirabilis	2 (0.5%)	-	-
Salmonella Spp.	-	1 (1.5%)	-
Enterococcus faecalis	1 (0.2%)	-	-

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Streptococcus pyogenes	-	1 (1.5%)	-
Total	420	69	28

Table 5: Antibiotic susceptibility pattern of gram-negative bacteria.

Isolated organisms	Antibiotic susceptibility pattern	AMK	IMI	NAL	CRO	GEN	AMP	CEX	CAZ	SXT
E. coli	R	6.7%	27.3%	62.7%	42.9%	18.6%	88.7%	74.2%	51.2%	61.5%
	I	29.3%	3.6%	-	2.3%	8.1%	-	3.2%	4.9%	7.7%
	S	64%	69.1%	37.3%	54.8%	75.8%	11.3%	22.6%	43.9%	30.8%
P. aeruginosa	R	3%	3.4%	37.9%	17.1%	10%	36.4%	37.5%	21.7%	63.6%
	I	-	3.5%	-	-	2.5%	3%	3.1%	-	-
	S	97%	93.1%	62.1%	82.9%	87.5%	60.6%	59.4%	78.3%	36.4%
K. pneumoniae	R	11.9%	44%	54%	45.3%	28.2%	92.7%	82.7%	60%	52.4%
	I	-	2%	2%	2.7%	7%	1.8%	1.9%	2.2%	9.5%
	S	88.1%	54%	44%	52%	64.8%	5.5%	15.4%	37.8%	38.1%
A. baumannii	R	4.5%	22.2%	47.4%	25%	12.9%	75%	50%	35.7%	4.5%
	I	-	-	5.2%	3.1%	-	-	-	-	-
	S	95.5%	77.8%	47.4%	71.9%	87.1%	25%	50%	64.3%	95.5%

Abbreviations: R, Resistance; I, intermediate; S, Sensitive; AMK, Amikacin; IMI, Imipenem; NAL, Nalidixic acid; CRO, Ceftriaxone; GEN, Gentamicin; AMP, Ampicillin; CEX, Cephalexin; CAZ, Ceftazidime; and SXT, Trimethoprim-Sulfamethoxazole.

Table 6: Antibiotic susceptibility pattern of gram-positive bacteria.

[DOR: 20.1001.1.23222913.2019.8.3.12.6]

Isolated organisms	Antibiotic susceptibility pattern	AMK	CRO	GEN	AMP	CEX	CAZ	VAN	SXT
S. epidermidis	R	4.3%	26.7%	16.1%	90.5%	60%	39.1%	10.5%	46.2%
	I	2.2%	1.6%	8.1%	7.1%	2.2%	-	-	-
	S	93.5%	71.7%	75.8%	2.4%	37.8%	60.9%	89.5%	53.8%
S. saprophyticus	R	-	25%	9.1%	-	100%	33.3%	12.5%	100%
	I	-	-	9.1%	-	-	-	-	-
	S	100%	75%	81.8%	100%	-	66.7%	87.5%	-
S. aureus	R	4.8%	28.9%	16.7%	95.1%	75.9%	39.1%	6.5%	66.7%
	I	-	2.2%	7.7%	-	1.7%	4.5%	-	5.5%
	S	95.2%	68.9%	75.6%	4.9%	22.4%	56.4%	93.5%	27.8%

Abbreviations: R, Resistance; I, intermediate; S, Sensitive; AMK, Amikacin; CRO, Ceftriaxone; GEN, Gentamicin; AMP, Ampicillin; CEX, Cephalexin; CAZ, Ceftazidime; VAN, Vancomycin; and SXT, Trimethoprim-Sulfamethoxazole.

[DOR: 20.1001.1.23222913.2019.8.3.12.6]