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ORIGINAL: Prevalence of Nosocomial Infections in Intensive Care Units in Shahid Sayyad-E-Shirazi Hospital of Gorgan During 2016-2018

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ABSTRACT

Introduction: Understanding the pattern of infections in the intensive care unit and the correct pattern of antibiotic use is vital in reducing mortality. Identification of risk factors for nosocomial infection and preventive approaches can be effective in reducing the incidence. This study aimed to evaluate the intensive care unit (ICU) acquired infection.

Material and Methods: This cross-sectional study was performed on patients admitted to the ICU of Sayyad Shirazi Hospital during 2016-18. All patients' information recorded and analyzed by SPSS version 16.

Results: In this study, the nosocomial infection rate was 3.5%, mostly in individuals over 60 years old. Most of the positive cultures were from two sources of urine and then blood. The organisms observed in nosocomial infections were *Escherichia coli* (16.9%), *Staphylococcus epidermis* (11.5%), *Enterococci*, and *Enterobacter*. The most commonly used antibiotics were vancomycin and then meropenem. Antibiogram results indicated the highest antibiotic resistance (100%) to cefazolin, piperacillin and clindamycin, and 96.8% to ceftriaxone. Vancomycin and amikacin had the lowest resistance.

Conclusion: According to the results of this study, the incidence of nosocomial infection is unavoidable, and its control is the most important health goals of medical centers. Proper treatment interventions are needed to reduce the impact of nosocomial infection.

Introduction

The application of antibacterial medications in the Intensive Care Unit (ICU) is up to 10-fold higher compared to the other departments of the hospital. Typically, 60-70 percent of ICU patients are receiving antibiotics at any given time (1). These can lead to increasing the rate of antibiotic use and its associated costs (2, 3). Infectious diseases are prevalent in the intensive care unit, and nosocomial infections are observed in 5-30% of patients. Diffuse or limited nosocomial infections caused by the reaction of hospital-acquired pathogens directly to the infectious agents or indirectly to the toxins in the hospital might occur within 48-72 hours after admission with no

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obvious symptoms of infection at the time of admission. Also, the disease should not be at the latency period (4). Although ICUs comprise less than 10% of all beds in most hospitals, more than 20% of all nosocomial infections occur in ICUs, causing a significant rate of morbidity and mortality. Gram-negative bacteria are among the leading causes of nosocomial infections, which widely investigated (5-7). However, the spread of these bacteria and origination in nosocomial infections still need further investigations. It is crucial to identify the cause of these infections, and their mode of spread, the type and amount of drug resistance of the bacteria, especially gram-negative organisms isolated from clinical specimens (8). Different investigations consider *pneumonia* as one of the most common infections in the hospital, with mortality rates up to 76% in some cases, such as those with mechanical ventilation (9, 10). The National Nosocomial Infections Surveillance (NNIS) of the United States describes nosocomial *pneumonia* as one of the most common infections in the intensive care unit. The extensive use of mechanical ventilation and tracheal intubation, especially in patients with critical conditions, leads to a high risk of hospital *pneumonia* (11). On the other hand, the use of implanted medical equipment in the patient's body (e.g., central venous catheter, foley catheter, and endotracheal tube) bypass the host's natural defense systems and act as an entry door for pathogens (12).

Understanding the pattern of infections in the ICU and the correct prescribing pattern of antibiotics, as well as identifying the right therapeutic strategies and types of infectious bacteria is of great importance. On the other hand, infections caused by antibiotic-resistant bacteria have become a global health concern and increased costs, duration of hospitalization, the severity of illness, morbidity, and mortality. Hence, identification of the nosocomial infections' risk factors and approaches to prevent them can reduce the incidence rate (13). In this regard, this study aims to evaluate the infections of the intensive care unit (the type of infection, culture results, antibiotics used, duration of treatment, and final results of treatment) in Shahid Sayyad-E-Shirazi Hospital of Gorgan from 2016 to 2018.

Methods

This descriptive/cross-sectional study was performed on patients diagnosed with an infection and treated with an antibiotic in ICU in Shahid Sayyad-E-Shirazi Hospital of Gorgan, Iran, from 2016 to 2018 using the census method. After applying the inclusion criteria (admission to ICU, no infection history before ICU admission, positive culture result, age more than 14 years old, complete patient records) and necessary permissions, patients' records were obtained from the Gorgan University of Medical Sciences. All the patients' information, including age, sex, cause of admission, initial diagnosis, final diagnosis, and duration of hospitalization, were recorded. Moreover, information about antibiotic application and type of culture (blood, urine, respiratory secretions, cerebrospinal fluid, stool, and pleural effusion) were recorded for the detection of bacteria, the method of antibiotic administration, and the type of antibiotic used.

Specimens transferred to the laboratory and were cultured in two blood agar and MacConkey agar media. The media were assessed after 24-48h incubation at 35±2°C. Differential diagnostic media were used to identify the genus and species of the bacteria (36). Data were analyzed using mean, standard deviation, frequency, percentage, and statistical graphs. The *Chi*-square test investigated the relationship between qualitative variables and different infections. SPSS software v. 16 (SPSS Inc., Chicago, IL, U.S.A.) was used for analyzes. The significance level of the study set at 0.05.

Results

This study was performed on the records of 1000 patients admitted to the ICU of Sayyed-

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E-Shirazi Hospital of Gorgan during 2016-2018. From the total number of patients, specimens were collected from 700 cases, and only 130 cases were culture-positive and showed nosocomial infection. These 130 cases included 56 males (43.1%) and 74 females (56.9%). The average age of patients admitted in this ward was 64.77 ± 16.47 years old, with a minimum age of 18 years and a maximum age of 95 years. In this study, the majority of positive samples were urine and blood specimens (***Table 1***).

Table 1. Frequency distribution of positive culture source of patients admitted to the ICU

Source	Frequency (%)
Urine	75 (57.7)
Blood	41 (31.5)
Sputum	8 (6.1)
Wounds	3 (2.3)
Pleural	1 (0.8)
Cvline	1 (0.8)
Stool	1 (0.8)
Total	130 (100)

Out of 130 patients admitted to the ICU with a positive culture, 47 gram-negative organisms (27.2%) were observed, most of which consisted of *Escherichia coli*, followed by *Enterobacter*. Besides, 25 patients were diagnosed with gram-positive organisms, consisted of *Staphylococcus epidermidis* and *Enterococcus*. Patients admitted to the ICU ward also showed positive fungal cultures, 51 cases were yeast-positive, and 2 cases were candida-positive (***Table 2***). Out of 130 patients admitted to ICU, 100% have used a urinary catheter, and 95.4% used a ventilator. According to Table 4, antibiogram analysis of positive culture specimens revealed that the highest antibiotic resistance was correlated to Cefazolin (100%), Piperacillin (100%), Clindamycin (100%), and Ceftriaxone (96.8%) respectively (***Table 3***).

Moreover, the most abundant source of gram-positive bacteria was blood samples. However, in positive cultures of gram-negative bacteria, a higher percentage of *Citrobacter* was isolated from sputum and blood. Positive fungal cultures were also found to be the most prevalent in urine samples (***Table 4***).

The *Pneumococcus* presented the highest resistance (100%) against aminoglycoside, fluoroquinolones, cephalosporins, and macrolide antibiotics. The positive culture organisms showed the lowest resistance towards anti-MRSAs, and from the microorganisms above, *Escherichia coli* showed 50% resistance against this antibiotic. Gram-negative microorganisms showed the highest antibiotic resistance (100%) to P.R.P.s, aminoglycosides, fluoroquinolones, cephalosporins, and macrolides (***Table 5***).

Table 2. Frequency distribution of organisms positive for nosocomial culture

Organisms		Frequency (%)
Gram-negative bacteria	**Escherichia coli**	22 (16.9)
	Enterobacter	10 (7.7)
	Pseudomonas	5 (3.8)
	Citrobacter	5 (3.8)
	Klebsiella	2 (1.5)
	Acinetobacter	2 (1.5)
	Proteus	1 (0.8)
	Total	47 (27.2)
Gram-positive bacteria	**Epidermis staph**	15 (11.5)
	Enterococcus	6 (4.6)
	Pneumococcus	3 (2.3)
	Staphylococcus aureus	1 (0.8)
	Total	25 (19.2)
Fungi	**Yeast**	61 (46.9)
	Candidate	2 (1.5)
	Total	53 (48.4)

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Table 3. Frequency distribution of antibiotic resistance in positive culture samples

Antibiogram	Frequency (%)	
	Resistant	Sensitive
Cefazolin	15 (100)	0
Piperacillin	15 (100)	0
Cephalothin	14 (100)	0
Clindamycin	16 (100)	0
Ceftriaxone	30 (96.8)	1 (3.2)
Nalidixic Acid	17 (94.4)	1 (5.6)
Co-amoxiclav	14 (93.3)	1 (6.7)
Cefotaxime	28 (93.3)	2 (6.7)
Imipenem	24 (92.3)	2 (7.7)
Cefalexin	20 (90.9)	2 (9.1)
Gentamicin	29 (90.6)	3 (9.4)
Ciprofloxacin	26 (89.7)	3 (10.3)
Ceftazidime	17 (89.5)	2 (10.5)
Norfloxacin	17 (89.5)	2 (10.5)
Nitrofurantoin	18 (81.8)	4 (18.2)
Carbenicillin	17 (89.5)	5 (22.7)
Amikacin	21 (65.6)	11 (34.4)
Vancomycin	0	4 (100)

Among the patients who died in the ICU, the majority of them showed positive results for blood and urine cultures. The table below also lists the most common organisms found in deceased patients (***Table 6***).

According to ***Table 7***, 56 gram-negative bacteria and 35 gram-positive and 117 fungal-positive cultures eventually died.

Also, 50% of positive urine cultures and 34.8% of positive blood cultures were in the age ranged from 30-60 years.

In this study, 16.7% of patients under 30 years and 23.9% of patients aged between 30-60 years were positive for gram-positive bacterial (***Table 8***).

In addition, 64.6% of patients with positive urine culture were hospitalized for less than one week, while 30% were hospitalized for more than one month. Moreover, 15% of *Enterococcus* positive, 30% of *Escherichia coli* positive, and 60% of fungal-positive patients were hospitalized for more than one month (***Table 9*** and ***Table 10***).

Discussion

In this study, the rate of nosocomial infection during 2016-2018 was reported at 13%. In studies conducted by Bijari et al. in the Birjand city, Darwishpour et al. in Torbat-E-Heydariyeh city, and Lari-Pour et al. in the Qom city it was reported 0.9%, 0.7%, and 0.49% respectively, which was lower than our results (14-16). On the other hand, in some other studies such as those conducted by Ghazvini et al. and Ghorbani et al. this rate was higher and closer to 10% (17, 18). The reasons for the differences in results reported by various studies might be due to the differences in the study periods and improvements in nosocomial care surveillance or the number and type of units under investigation (16).

In this study, more than half of the patients with nosocomial infections were female and aged more than 60 years old, which was in accordance with the results of Kermani Burjani's study in 2015, Ghorbanali Zadegan's survey in 2005 and Laripour's in 2007 (14, 19, 20). Older adults are more susceptible to this infection due to changes in their cellular and humoral immune system, physiological changes (reduction of cough reflexes), abnormalities in blood flow and delayed wound healing (21).

In the present study, most of the positive cultures were collected from urine and blood samples. In Darvishpur's study (15), the most prevalent nosocomial infections were related to surgical wounds, with a smaller percentage

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Table 4. Frequency Distribution of Positive Culture Organisms for Nosocomial Infection Based on Positive Culture Origin in Patients with Nosocomial Infections in Intensive Care Units

Organism		Blood	Urine	Pleural	Sputum	Stool	CV-line
Gram-negative organisms	**Epidermis Staph**	13 (31.7%)		-	2 (3.3%)	-	-
	Enterococcus	2 (4.9%)	4 (5.3%)	-	-	-	-
	Pneumococcus	1 (2.4%)	-	-	-	-	-
	Staphylococcus aureus	2 (4.9%)	1 (16.7%)	-	-	-	-
	Escherichia coli	-	2 (2.7%)	-	-	-	-
	Enterobacter	10 (24.4%)	10 (13.3%)			1 (100%)	-
	Pseudomonas	6 (14.6%)	2 (2.7%)	-	2 (3.3%)	-	-
Gram-positive organisms	**Citrobacter**	2 (4.9%)	2 (2.7%)	-			1 (100%)
	Klebsiella	1 (2.4%)	-	1 (16.7%)	-	-	-
	Acinetobacter	1 (2.4%)	-	-	2 (33.3%)		-
	Proteus	1 (2.4%)	-	-	-	-	-
Fungi	**Yeast**	8 (19.5%)	51 (68%)	-	1 (33.3%)	-	-
	Candidate			-	-	-	-

of self-reported urinary and blood infections. Pleurisy and sputum specimens were the most prevalent in the study of Bijari and Ghorbanali Zadegan (16, 19). In a survey conducted by Sohrabi *et al*. (22) as well as the Laripour's study (14), the majority of the positive cultures for nosocomial organisms were collected from urine samples, in which pneumonia was the second most prevalent nosocomial infection. Most studies in this field have reported lower surgical site infections, which is in accordance with the present study (23).

In this study, the most common organisms observed in nosocomial infections were *Escherichia coli*, *Staphylococcus epidermis*, *Enterobacter*, and *Enterococcus*, respectively. The most common microorganisms found in urine and blood cultures were *Escherichia coli* and gram-positive cocci, respectively (14). In the Ghorban-Ali-Zadegan study, the most prevalent bacterial isolates were *Staphylococcus aureus*, *Pseudomonas Aeruginosa*, *Acinetobacter*, and *Klebsiella* pneumonia (19). In Bijari's research, the pathogens causing infection were *Klebsiella*, Pseudomonas, *Escherichia coli*, and Staphylococcus aureus, respectively (16).

In general, the most common microorganisms causing nosocomial infections vary based on the location of the infection, in which viral, bacterial, and fungal factors play an important role (24, 25). According to global studies, viral infections are substantially isolated in wounds. In other studies, the most common microorganisms responsible for the nosocomial infection are *Escherichia coli*, gram-negative cocci, and *Acinetobacter* (14, 16), which is in the same line with the present study. In our study, the level of fungi was significantly high, which is justified by the origin of the infection (urine samples).

In the present study, the most commonly used antibiotics were vancomycin, followed by meropenem. In another study, the most widely used antibiotics were vancomycin, ceftriaxone, imipenem, and clindamycin, which was consistent with the present study (15). In this study, antibiogram results showed the highest antibiotic resistance against cefazolin, piperacillin, clindamycin with 100% resistance, and ceftriaxone with 96.8% resistance. The lowest resistance was observed against vancomycin and amikacin. Therefore, it can be concluded that cefazolin and ceftriaxone should not be used in the treatment of nosocomial infections in the

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ICU. In the study performed by Habibian *et al*. in 2008, the antibiogram results of ICU admitted patients showed resistance to zoxim and ciprofloxacin, with 88% and 55%, respectively (26). Antibiotics resistance is highly prevalent regarding third-generation cephalosporins and fluoroquinolones.

In this study, 47% of patients were hospitalized for one week to 30 days. On the other hand, the results showed a higher percentage of patients with positive blood culture were admitted for one week to 30 days, that indicates the deterioration of general conditions of the patients, which has been less than one week for urine cultures. The microorganisms correlated to prolonged hospitalization in ICU patients include *Escherichia coli* (30%), *Enterococcus* (15%), *Enterobacter* (15%), *Pseudomonas* (5%), and fungal factors. In the study of Pezeshkian *et al*. in 2009 (27), the average duration of hospitalization in the ICU was 18.7 ± 30 days, which is consistent with the present study. Nosocomial infection, ventilator use, and history of previous illness were the associated factors that increased the length of hospital stay (28).

In this study, 100% and 95.4% of patients used urinary catheters and ventilators during hospitalization, respectively. Given that a high percentage of patients with nosocomial infection used endotracheal suctioning, ventilator, and urinary catheters; It can be inferred that these therapies make patients more susceptible to the infection.

Moreover, approximately 90% of patients experiencing an infection in the ICU. It was reported that the majority of dead patients showed positive urine (59%) and blood cultures (31%). The most common organisms observed in their cultures included *Staphylococcus epidermis* (10.3%), *Escherichia coli* (17.1%), and fungi. According to the investigations, urinary tract infections are the most common and fatal nosocomial infections as well as the leading cause of death (28, 29). In our study, however, urinary tract infection was the second leading cause of death. Hence, the mentioned findings illustrate the importance of preventing urinary tract infections in the ICU.

In the present study, 10% of patients with nosocomial infection survived and recovered. Assessments in the multinational studies have revealed that the mortality rates in the ICU vary from 7% to 20% (28, 30), while this percentage was higher in the present study. It seems that there are other factors such as the presence of underlying diseases, the older age of patients, and the severity of the disease that contribute to the morbidity and mortality of hospitalized patients.

Conclusion

According to the results of this study, the incidence of nosocomial infections in medical centers is inevitable, and one of the highly essential health goals of medical centers is to control and manage this phenomenon. To decrease the incidence of nosocomial infection, on time and proper therapeutic interventions are needed, and the application of catheters should be reduced. Given the sensitivity of the ICU ward, full health care should be taught to the medical staff in these units. In addition, the antibiotic application should be controlled.

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Conflicts of interest

The authors declare that there is no conflict of interest regarding the publication of this article.

Authors' contributions

All the authors contributed equally to this manuscript.

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Table 5. Frequency (%) distribution of antibiotic resistance based on organisms in patients with nosocomial infections in intensive care units

Antibiotic category	Gram-positive organisms				Gram-negative organisms							Fungi	
	Epidermis Staph	*Enterococcus*	*Saprophyte*	*Pneumococcus*	*Klebsiella*	*Escherichia coli*	*Enterobacter*	*Pseudomonas*	*Acinetobacter*	*Citrobacter*	*Proteus*	*Yeast*	*Candidate*
Aminoglycosides	14 (93.3)	5 (83.3)	-	3 (100)	1 (50)	15 (68.2)	5 (50)	3 (60)	2 (100)	4 (80)	1 (100)	51 (83.6)	2 (100)
Piperacillin	12 (80)	3 (50)	-	3 (100)	2 (100)	20 (90.9)	7 (70)	5 (100)	2 (100)	5 (100)	1 (100)	48 (78.8)	-
Anti-MRSA	3 (20)	2 (33.3)	-	1 (33.3)	1 (50)	10 (45.5)	-	1 (20)	-	-	-	24 (39.3)	-
Anti-fungal	15 (100)	4 (66.7)	1 (100)	3 (100)	1 (50)	18 (81.8)	9 (90)	4 (80)	2 (100)	5 (100)	1 (100)	51 (83.6)	-
Anti-aerobic	4 (36.7)	-	-	3 (100)	1 (50)	11 (50)	4 (40)	2 (40)	1 (50)	5 (100)	1 (100)	18 (29.5)	-
Monobactam	9 (60)	1 (16.7)	0	3 (100)	0	7 (31.8)	2 (20)	-	1(50)	4 (80)	1 (100)	22 (36.1)	1 (50)
Fluoroquinolone	13 (86.7)	5 (83.3)	1 (100)	2 (66.7)	2 (100)	16 (72.2)	7 (70)	3 (60)	2 (100)	5 (100)	1 (100)	47 (77)	-
Cephalosporin	10 (66.7)	3 (50)	1 (100)	3 (100)	1 (50)	13 (59.1)	6 (60)	5 (100)	1 (50)	5 (100)	-	37 (60.7)	1 (50)
Macrolide	9 (60)	5 (83.3)	1 (100)	1 (33.3)	1 (50)	14 (63.6)	4 (40)	5 (100)	1 (50)	2 (40)	1 (100)	46 (75.5)	2 (100)

Table 6. Frequency (%) distribution of final outcome patients with nosocomial infections based on positive culture source

Source	Died	Improve
Blood	37 (31.6)	4 (30.8)
Urine	69 (59)	69 (59)
Pleural	1 (0.9)	-
Sputum	5 (4.3)	1 (7.7)
Stool	1 (0.9)	-
BAL	2 (1.7)	-
CV-line	-	-

Table 7. Frequency (%) distribution of ultimate outcome patients with nosocomial infections based on organism type

Organism		Died	Improve
Gram-negative organisms	Klebsiella	2 (1.7)	-
	Escherichia coli	20 (17.1)	2 (15.4)
	Enterobacter	10 (8.5)	-
	Pseudomonas	4 (3.4)	1 (7.7)
	Acinetobacter	2 (1.7)	-
	Citrobacter	4 (3.4)	1 (7.7)
	Proteus	1 (0.9)	-
	Total	56 (26.7)	4 (30.8)
Gram-positive organisms	Epidermitis	12 (10.3)	3 (23.1)
	Enterococcus	6 (5.1)	-
	Saprophyte	1 (0.9)	-
	Pneumococcus	3 (2.6)	-
	Total	35 (19.8)	3 (23.1)
Fungi	Yeast	57 (48.7)	4 (30.8)
	Candidate	2 (1.7)	-
	Total	117 (100)	13 (100)

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Table 8. Frequency (%) distribution of age groups of patients with nosocomial infections by organism type

Organism		Age Groups		
		<30 Year	30-60 Year	>60 Year
Gram-positive organisms	Epidermitis	1 (16.7)	8 (17.4)	6 (7.7)
	Enterococcus	-	2 (4.3)	4 (5.1)
	Saprophyte	-	-	1 (1.3)
	Pneumococcus	-	1 (2.2)	2 (2.6)
	Total	6 (100)	46 (100)	78 (100)
Gram-negative organisms	Klebsiella	-	-	2 (2.6)
	Escherichia coli	1 (16.7)	11(23.9)	10 (12.8)
	Enterobacter	-	4 (8.7)	6 (7.7)
	Pseudomonas	-	1 (2.2)	4 (5.1)
	Acinetobacter	-	1 (2.2)	2 (2.6)
	Citrobacter	1 (16.7)	3 (6.5)	1 (1.3)
	Proteus	-	1 (2.2)	-
	Total	6 (100)	46 (100)	78 (100)
Fungi	Yeast	2 (33.3)	19 (41.3)	40 (51.3)
	Candidate	-	-	2 (2.6)
	Total	6 (100)	46 (100)	78 (100)

Table 9. Frequency (%) distribution of hospital infection patients based on positive culture source

Source	Duration of hospitalization		
	Less than a week	One week to 30 days	More than 30 days
Blood	12 (25)	23 (37.1)	6 (30)
Urine	31 (64.4)	32 (51.6)	12 (60)
Pleural	1 (2.1)	-	-
Sputum	2 (4.2)	4 (6.5)	-
Stool	1 (2.1)	-	-
Bal	-	1 (1.6)	1 (5)
CV-line	-	-	1 (5)
Wound	1 (2.1)	2 (3.2)	-
Total	48 (100)	62 (100)	20 (100)

Table 10. Frequency distribution of hospitalized infection patients based on type of organism

Organism		Duration of hospitalization		
		Less than a week	One week to 30 days	More than 30 days
Gram-positive organisms	Epidermitis	4 (8.3)	10 (16.1)	1 (5)
	Enterococcus	-	3 (4.8)	3 (15)
	Saprophyte	-	1 (1.6)	-
	Pneumococcus	3 (3.6)	-	-
Gram-negative organisms	Klebsiella	1 (2.1)	-	1 (5)
	Escherichia coli	8 (16.7)	8 (12.9)	6 (30)
	Enterobacter	-	7 (11.3)	3 (15)
	Pseudomonas	1 (2.1)	3 (4.8)	1 (5)
	Acinetobacter	1 (2.1)	1 (1.6)	-
	Citrobacter	2 (4.2)	3 (4.8)	-
	Proteus	-	-	1 (5)
Fungi	Yeast	19 (39.6)	30 (48.8)	12 (60)
	Candidate	-	2 (3.2)	-

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