A Comparative Analysis of Nosocomial Infections between Internal and Surgical Intensive Care Units of University Hospitals in Birjand, Iran from 2016 to 2017: A Retrospective Study

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Abstract

Introduction: This research was a retrospective study on the prevalence of nosocomial infections (NIs) and the associated risk factors among the patients admitted to the surgery and internal Intensive Care Units (ICU).
Materials and Methods: This cross-sectional descriptive study was conducted on patients admitted to ICUs over one year. Clinical data of patients, including demographic information, length of stay, underlining disease, the rate of patients with NIs and distribution of NIs sites and pathogens were collected. Univariate and multivariate logistic regression were run to determine the factors associated with NIs.
Results: Collectively, 1018 patients were studied, including patients admitted to surgical ICU (n = 665) and internal ICU (n = 353). The incidence rate of NI in the surgical and internal ICUs was 67 (10.1%) and 96 (27.2%), respectively. The most NIs in the internal ICU were respiratory tract infections (RTI, 46.9%) and urinary tract infections (UTI, 37.5%), while the common infections in the surgical ICU were respiratory tract infections (RTI, 38.3%) and surgical-site infections (SSI, 22.0%), respectively. The major risk factors, length of stay and use of nasogastric intubation (NG tubes), were associated with NIs in both ICUs.
Conclusion: Our results indicated that the incidence of infections in the internal ICU was more than the surgical ICU. Age, underlying diseases, the long stay, and use of ventilator and NG tube were of factors associated with NIs rate in internal ICU.

Keywords: Nosocomial Infections, Risk factors, Intensive care units, Medical devices

Introduction

Hospital-acquired infections are also called nosocomial infections (NIs) occur in patients under medical care in hospital (1). NIs is considered as an important health problem issue worldwide, and also, this type of infection occurs in the patients under medical cares in hospitals. Based on the National Nosocomial Infection Surveillance (NNIS) system, these infections can be classified into four major groups as follows: pulmonary, urinary tract, blood stream, and surgical site infections (1). Most of the NIs frequently was occurred (above 20%) in intensive

care units (ICU) (2). In this regard, invasive devices such as catheters and ventilators employed in modern health care can cause these infections (3).

Today, NIs is among the major challenges in hospitals and medical centers, and are also considered as a significant cause of the increased mortality and morbidity rates. According to World Health Organization (WHO) investigation in 55 hospitals from 14 countries, it was indicated that, on average, 8.7% of the hospitalized patients had NIs. Over 1.4 million people worldwide are suffering from the complications of nosocomial infection (4). In previous studies, the highest prevalence of NIs was reported in ICU, surgical, and orthopedics units (5). Moreover, the most frequent kinds of infections include central line-associated blood system infections, catheter-associated urinary tract infections, surgical site infections, and ventilator–associated pneumonia (6).

Pathogens responsible for NI are some types of bacteria, viruses, and fungi, which are mainly opportunistic and show a high rate of resistance to the antimicrobial medicines (7). Moreover, these microorganisms can be colonized on medical devices such as intravenous and urinary catheters, mechanical ventilation tubes, and nasogastric tubes (NG tube) (8). On the other hand, there are a lot of predisposing factors such as increase in the prolonged hospital stay, long term disability, the increased antimicrobial resistance, which all of them may lead to the increased chance of NIs occurrence (9). Due to the special circumstances of patients admitted to intensive care units, it is necessary to correctly identify these risk factors and to adopt appropriate preventive measures.

Internal intensive care units (I-ICUs) and medical surgical intensive care units (MS-ICUs) are two medical units, which are usually considered as unites with the relatively high rate of NIs. Therefore, we aimed of present study was to compare the rate of incidence NI and risk factors in the I-ICU and MS-ICU.

Materials and Methods

Study Subjects

This cross-sectional and descriptive study was conducted on patients admitted at MS-ICU and I-ICU of the university hospitals of Birjand, Iran from 2016 to 2017. The study was the result of two research works with medical ethics code (IR.BUMS.REC.1394-17 and IR.BUMS.REC.1394-27). All patients with the initial positive culture as well as patients who had taken antibiotics for any reason in the past 72 hours were excluded from the study. Demographic data and clinical status (e.g., age, gender and length of stay) were recorded at admission to the ICU. The written consent was received from all of the patients or their first relatives. The patients' names and personal information were kept confidential.

In this study, the samples included all blood, urine, sputum and wound were initially taken before antibiotic administration from patients hospitalized in the MS-ICU and I- ICU. In addition, the detailed information about types of medical devices used, such as urinary catheters and mechanical ventilation tube, central venous catheter, NG tube, and blood transfusion were recorded.

A number of patients admitted to the ICU from 2016 to 2017 were excluded in the study due to taking antibiotics. There were cases appeared to be infected but did not have a positive culture which were also excluded from the study.

The types of infections were diagnosed on the basis of clinical suspiciousness, radiological information and were confirmed by biochemical criteria, like positive cultures from different samples. Major infections, such as respiratory tract infections (RTIs), wound/ surgical-site infections (SSIs), blood stream infections (BSIs) and urinary tract infections (UTIs) diagnosed as follows:

RTIs included infections involving respiratory tract including bronchitis, pneumonitis and pneumonia; SSI included non-healing wound with or without discharge involving the sterna wound and/or leg or arm and culture positive from the discharges; BSI included positive pathogen-cultures of blood samples, each taken from one central and one peripheral site; UTI included more than 10^5 colony forming unite (CFU) pathogen on culture.
For bacterial and fungal identification, the samples collected from patients, transferred to the hospital microbiological laboratory and were cultured in the lab according to the standard procedures. After 48 hours, re-sampling was performed for patients who their samples initially showed negative prototype culture. In the next stage, all positive cultures were isolated and the microbial isolates were conducted to biomedical tests for identification the pathogens in a species level.

Statistical Analysis

The collected data were statistically analyzed by SPSS (V. 22) software using Chi-square and t-test. The normality of numeric variables was checked by Kolmogorov-Smirnov test. The association between NIs and potential risk factors was identified by Chi-square test in univariate analysis. Variables significantly different between two groups were analyzed in a forward stepwise logistic-regression model to confirm independent risk factors associated with NIs. Logistic regression analysis was performed to calculate the odds ratio (OR) and 95% confidence interval (CI) by using NIs as a dependent variable and the clinical data (i.e., demographic information, used of medical devices) as independent variables. For all statistical analyses $P < 0.05$ was considered significant.

Results

During the study period (2016 to 2017), 1018 patients were admitted into the ICU from which 353 patients (mean age: 53.8 ± 23.1years old) belonged to the I-ICU, and 665 patients (mean age: 46.1 ± 26.0 years old) belonged to the MS-ICU. The demographic and baseline ICU data of the patients are given in Table 1. The most common causes of hospitalization in the ICUs were hypertension and chronic pulmonary heart disease, whereas in the I-ICU, frequency of hyper tension and chronic lung disease were 41.1% and 22.1%, respectively. As well as, in return hospitalized patients, the common underlying diseases in MS-ICU were hyper tension and heart disease with frequency of 31.1% and 23.5%, respectively. Moreover, a statistically significant correlation was observed between the groups ($P < 0.001$).
The average length of hospital stay in I-ICU patients were 8.73 ± 7.46 days, and in MS-ICU were 8.11 ± 4.8 days, which was significantly higher among the I-ICU patients compared to the surgical ICU patients ($P = 0.01$). In both internal and MS-ICU, the prevalence of NIs significantly increased with the increase of age and hospital stay. The results showed that, 11.6% of I-ICU and 11.7% of MS-ICU patients belonged to the age group of 71-80 years old. On the other hand, 71.2% of I-ICU patients and 65.8% of surgical ICU patients with a hospital stay of more than 10 days had a positive culture infection. Notably is that, as the length of hospital stay in both groups increased, positive culture infection has also increased ($P < 0.001$, Table 2).
According to results of the positive culture, the prevalence of nosocomial infections in the I-ICU was 27.2% (92/ 353), and in MS-ICU was 10.1% (68/665).

Table 1. Demographic and clinical characteristics of patients admitted to internal intensive care units (I-ICUs) and medical surgical intensive care units (MS-ICUs).

Characteristics	MS-ICU	Internal ICU	Total	P value
Age				**> 0.001**
<=20	135 (20.3)	21 (5.9)	156 (15.32)	
21-30	93 (14.0)	53 (15.0)	146 (14.34)	
31-40	79 (12.0)	60 (17.0)	139 (13.65)	
41-50	48 (7.2)	25 (7.1)	73 (7.1)	
51-60	72 (10.8)	36 (10.2)	108 (10.6)	
61-70	82 (12.3)	53 (15.0)	135 (12.23)	
71-80	92 (13.8)	41 (11.6)	133 (13.06)	
>=80	64 (9.6)	64 (18.1)	128 (12.60)	
Gender				**> 0.001**
Female	229 (34.4)	196 (55.5)	425 (41.74)	
Male	436 (65.6)	157 (44.5)	593 (58.25)	
Long term of stay in ICU (days)				**> 0.001**
1-2	221 (33.2)	68 (19.3)	289 (28.38)	
3-4	160 (24.1)	109 (30.9)	269 (26.42)	
5-6	131 (19.7)	62 (17.6)	193 (18.95)	
7-10	81 (12.2)	48 (13.6)	129 (12.62)	
>10	72 (10.8)	66 (18.7)	138 (13.60)	
Underlining disease				
Diabetes	91 (13.7)	59 (16.7)	150 (14.73)	**> 0.001**
Cancer	113 (17.0)	17 (4.8)	130 (12.81)	**> 0.001**
Heart disease	155 (23.3)	58 (16.4)	213 (21.0)	
Chronic lung disease	140 (21.1)	78 (22.1)	218 (21.42)	**> 0.001**
Kidney disease	45 (6.8)	20 (5.7)	65 (6.36)	**> 0.001**
Hypertension	206 (31.0)	145 (41.1)	351 (34.47)	**> 0.001**
Risk factors				**> 0.001**
Urinary catheter	665 (100)	353 (100)	1018 (100)	
Peripheral catheter	665 (100)	353 (100)	1018 (100)	
Tracheal tube	262 (39.6)	177 (50.1)	439 (43.12)	
Chest tube	72 (11.1)	3 (0.8)	75 (7.36)	
NG tube	438 (65.6)	218 (61.8)	656 (64.44)	
Transfusion	172 (25.9)	28 (7.9)	200 (19.64)	
Central catheter	66 (9.9)	9 (2.5)	75 (7.36)	
Recovery	552 (83.0)	183 (51.87)	735 (72.2)	**> 0.001**
Mortality	113 (17.0)	170 (48.2)	283 (27.8)	**> 0.001**

Data are presented as number (percent).

The most common nosocomial infections in the I-ICU are RTI (46.9%) and UTI (37.5%), while in the MS-ICU the most common infection is RTI (38.3%) followed by RTI&SSI (22.0%). The prevalence of nosocomial infections was significantly higher in the I-ICU compared to the MS-ICU ($P < 0.001$) (Table 2).

The majority of microorganism was detected from the I-ICU samples including *Pseudomonas aeruginosa (P. aeruginosa)* that was isolated from wound infections and pulmonary secretions and *Candida* spp that were detected from UTI. Whereas, in MS-ICU, *P. aeruginosa* was the most frequently isolated pathogen from wound infection (17.5%), the data was shown in Figure 1.

To identify the variables associated with NIs rates, a stepwise logistic regression analysis was performed separately in surgery and internal ICUs. Univariate analysis was performed with NIs status in ICUs as the dependent variable and potential NIs related indices (i.e., infection, age, gender, length of stay, hypertension, chronic of heart disease, chronic of lung disease, chronic of renal disease, diabetes, cancer, blood transfusion, used of chest tube, NG tube, tracheal tube, central catheter) as the independent variable.

To identify the variables associated with NIs rates, a stepwise logistic regression analysis was performed separately in surgery and internal ICUs.

Table 2. Frequency of nosocomial infection (NI) cases according to rate and infection type in I-ICUs and MS-ICUs.

Characteristics	MS-ICU	I-ICU	P value
Age			**0.01**
<10	3 (4.7)	0	
11-20	3 (4.7)	3 (14.3)	
21-30	16 (17.2)	10 (18.9)	
31-40	9 (13.2)	11 (18.3)	
41-50	9 (13.2)	4 (16.0)	
51-60	10 (13.9)	11 (18.3)	
61-70	6 (7.3)	15 (28.3)	
71-80	8 (11.7)	19 (46.3)	
>=80	4 (6.2)	23 (35.9)	
Gender			**0.13**
Female	20 (8.6)	47 (24.0)	
Male	48 (11)	49 (31.2)	
Long term of stay in ICU (days)			**0.001**
1	0	0	
2	1 (0.6)	7 (10.3)	
3-5	3 (2.3)	10 (9.2)	
5-10	16 (19.8)	32 (33.3)	
>10	48 (65.8)	47 (71.2)	
Diabetes	5 (5.5)	26 (44.1)	**0.001**
Cancer	7 (6.1)	1 (5.9)	**0.04**
Heart disease	5 (3.2)	21(36.2)	**0.09**
Chronic lung disease	0	24 (30.8)	**0.42**
Kidney disease	2 (4.4)	10 (50.0)	**0.02**
Hyper tension	10 (4.8)	58 (40.0)	**0.001**
Type of NIs			**0.001**
RTI	26 (38.3)	45 (46.9)	
SSI	9 (13.2)	5 (5.2)	
BSI	-	10 (10.4)	
UTI	-	36 (37.5)	
RTI and SSI	15 (22.0)	-	
UTI and SSI	7 (10.3)	-	
UTI and RTI	4 (5.3)	-	
Mixed NIs	7 (10.3)	-	

Data are presented as number (percent). MS-ICU, medical surgery intensive care unit; RTI, respiratory tract infections; UTI, urinary tract infections; BSI, blood stream infection; SSI, Surgery Site Infection.

Univariate analysis was performed with NIs status in ICUs as the dependent variable and potential NIs related indices (i.e., infection, age, gender, length of stay, hypertension, chronic of heart disease, chronic of lung disease, chronic of renal disease, diabetes, cancer, blood transfusion, used of chest tube, NG tube, tracheal tube, central catheter) as the independent variable. The results of MS-ICU suggested that age, gender (female vs. male) underlining disease (no have *vs.* have), blood transfusion (unused *vs.* used) and central venous catheter (unused *vs.* used), chest tube and tracheal tube (unused *vs.* used) were not related to NIs in ICU (P > 0.05). But infection (negative-culture *vs.* positive culture; OR = 0.40; 95% CI = 0.16-0.96; P = 0.045), the length of stay (OR = 1.20; 95% CI =1.05-1.38; P = 0.006), and NG tube (OR = 0.86; 95% CI = 0.74-1.00; P = 0.049) were factors associated with NIs in surgical ICU. The results of multivariate analysis also demonstrated that the only risk factors for NIs in MS-ICU are infection (negative-culture *vs.* positive culture; OR = 0.40; 95% CI = 0.16-0.96; P = 0.04), the length

of stay (OR = 0.83; 95% CI = 0.73-0.75; P= 0.006), and NG tube (OR= 1.17; 95% CI = 1.00-1.36; P = 0.049).

The results of logistic regression analysis in I-ICU suggested that infection (negative-culture *vs.* positive culture), gender (female *vs.* male), hypertension (no have *vs.* have), chronic of heart disease(no have *vs.* have), chronic of renal disease (no have *vs.* have), diabetes (no have *vs.* have), blood transfusion(no have *vs.* have), chest tube (unused *vs.* used) and central venous catheter(unused *vs.* used) were not related to NIs in internal ICU (P > 0.05), but age (OR = 0.96; 95% CI= 0.95-0.98; P < 0.001), the length of stay (OR = 0.67; 95% CI = 1.38-2.02; P < 0.001), chronic of lung disease (no have *vs.* have; OR = 0.34; 95% CI = 0.16-0.72; P = 0.005)1, cancer (no have *vs.* have; OR = 0.04; 95% CI = 0.00-0.32; P = 0.003), NG tube (OR = 0.68; 95% CI = 0.57-0.81; P < 0.001) and tracheal tube (OR = 0.84; 95% CI = 0.76-0.92; P < 0.001) were factors associated with NIs in I-ICU. The results of multivariate analysis also demonstrated the same variable as risk factors for NIs in I-ICU.

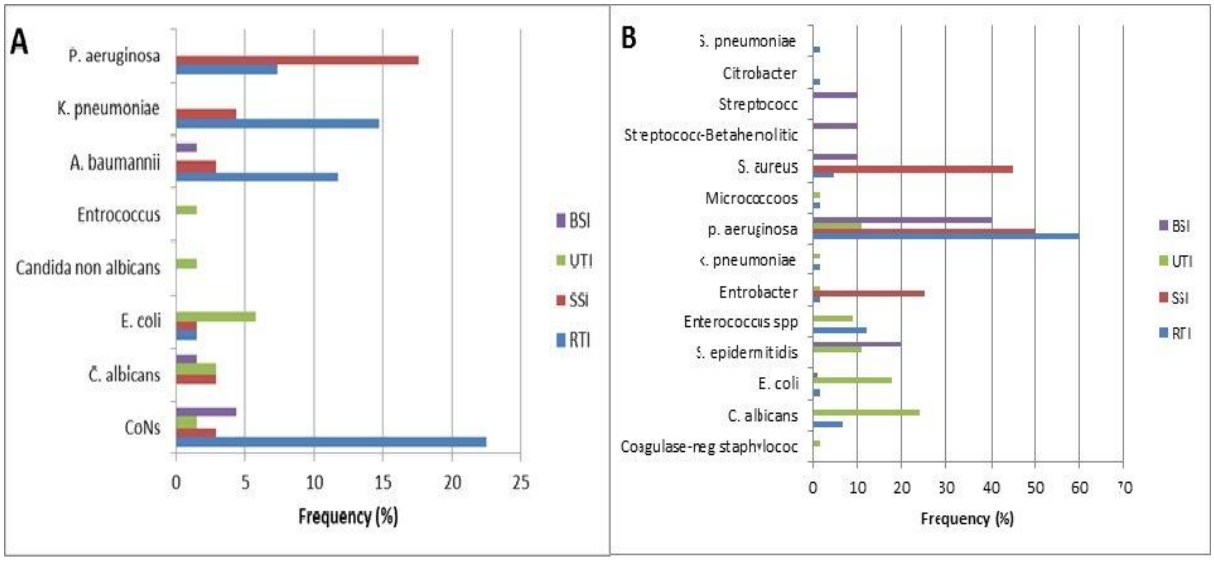

Figure1. Distribution of causative microorganisms isolated from sites of infections in intensive care units (ICUs). **A:** medical surgery intensive care unit (MS-ICU), **B:** Internal intensive care unit (ICU). RTI, respiratory tract infections; UTI, urinary tract infections; BSI, blood stream infection; SSI, Surgery Site Infection; CoNs, Coagulase negative staphylococcus.

Discussion

Despite progress in modern medical techniques and clinical application of various surgical operations, NIs is considered as a major risk factor for the prognosis of patients (1). It is also notable that, NIs might not only be in/directly the critical cause mortality, but also effected the treatment or operation of the patients, and increased prolong their hospitalization. The primary objective of present study was to investigate the rate of NIs in two type of ICU (internal and medical surgery), and analysis the related risk factors. We observed that, infection (positive culture) incidence between I-ICU and MS-ICU was 27.2% and 10.2%from 2015 to 2016, respectively. Previous studies have demonstrated that, the suffering of infection in the I-ICU was greater than the MS-ICU, which was significant (7, 9, 10-12).

In addition, we observed that, a variety of risk factors may be associated with the occurrence of NI such as the length of stay and use of medical devices (NG tube and ventilator). Therefore, we should pay more attention to the affecting factors of the patients in ICU, who are known as the

group with the high risk of NI. In our study, we demonstrated that, there was a significant relationship between the length of stay two ICUs and infection (p-value <0.001). Also, there was no significant difference between the two groups in terms of age and gender; however, a relationship between age and the rate of infection was significant (p-value <0.001). Ott et al. have revealed that, length of ICU stay was as one factor in occurrence of infection in I-ICU (13). Increasing the length of stay in the ICU, both spontaneously and through the longer usage of ventilator and NG tube, can be considered as a factor in increasing I-ICU infections compared to MS-ICU.

Moreover, in our study and other studies (10, 11, 13, 14-16), observed a direct relationship among the age, length of ICU stay, duration of catheterization, and infection, so that in both ICUs, this relationship was significant (p <0.001), so that the most common type of infection were UTI and RTI in each of ICUs (Table 2). The presence of underlying diseases in I-ICU patients can be one of the causes of more infections in this group. In our study, in I-ICU, hypertension was found to be the most common underlying disease followed by the chronic lung disease, diabetes, and heart diseases. However, hypertension identified the most common underlying disease followed by heart disease, chronic lung disease, and cancer at MS-ICU (Table 2). In this regard, diabetes can cause people become more susceptible to further infection, as well as to the dangerous non-common pathogens, due to cellular immune deficiency and the increased susceptibility to infection, along with the need for long-term hospitalization for sugar control and also the need for broad-spectrum antibiotics. (17).

In our study, we found that, the most common infections in I-ICU were RTI and UTI. On the other hand, the most common infections in MS-ICU were RTI and SSI. High prevalence of RTI and pneumonia in both ICUs in our study and other studies is due to the long-term patient's intubation. Patients who use mechanical ventilation or intubation are prone to pneumonia or nosocomial pneumonia. In a preview study, the most common infection in both ICUs was pneumonia followed by UTI and septicemia and SSI, respectively (11, 18, 19). In the present study, *Candida* spp. was the most frequent isolated pathogens for UTI, and *P. aeruginosa* was the most common pathogens for RTI, BSI, and SSI. In MS-ICU *E. coli* was the most isolated pathogens for UTI, *P. aeruginosa* was the most common pathogens for RTI, and *Staphylococci* and *Klebsiella* spp. were responsible for most of the BSI and SSI (Figure 1). According to previews studies, *P. aeruginosa* was the most common pathogens that isolates from variety samples in ICU patients, followed by *Staphylococci*, *Klebsiella*, *E. coli* were as the common agents of infection (7, 20, 2).

As it is evident in our study, on the hospital-acquired infection, there is a little difference was observed between both of ICUs. More importantly, *Enterobacteriaceae*, especially *Pseudomonas* and *Actinobacteria* which have sometimes multidrug resistance, and resistance of *Staphylococci* to methicillin, are the most common organisms isolated from patients admitted in the ICUs. On the other hand, *Candida* spp, which causes infections in the patients with immunodeficiency and those with the long-term use of antibiotics, has been known as the important pathogen cause of NIs. Hence, these results are not far-fetched due to the long hospital stay in the internal ICU and the use of broad-spectrum antibiotics in these patients, as well as the specific underlying diseases like diabetes in our study.

Notably, the incidence of NI in I-ICU was significantly more than MS-ICU. In this regard, we should pay more attention to the influencing factors of critical patients

who admitted in I-ICU. In this study, we found that length of ICU stay and used of NG tube were related with NIs rate in MS-ICU. However, age, the length of ICU stay, underlying disease, used of NG tube and ventilator were factors associated with NIs rate in I-ICU. In terms of mortality, 62.5% of the patients in the I-ICU had positive culture and 48.4% had no infection, and in the MS-ICU 39.7% of the patients had positive culture and 14.3% had no infection, which was a significant difference (p-value <0.001). In previous studies indicated that, NIs rate with increasing of infection (positive-culture) in internal ICU had a significant difference (22-26). Therefore, we should be undertaken to monitor and reduce the affecting factors of the patients in ICUs, who are known as the group with the high risk susceptible to NI.

Conclusion

In our study, it was demonstrated that, prevalence of NI was more in the I-ICU compared to the MS-ICU. Age, underlying diseases, the long stay, used of ventilator and NG tube were factors associated with NIs rate in I-ICU. Therefore, we should pay more attention to the influencing factors of critical patients who admitted in I-ICU. It is recommended to, as much as possible to reduce the length of hospital stay in the ICU. If possible, reducing the time of the patients use medical equipment, and replacing it will reduce the possibility of bacterial and fungal colonization, as well as, the application of appropriate prophylaxis for patients prone to infection can be effective in reducing nosocomial infections.

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Conflict of Interest

The authors declare that they have no competing interests.

Authors' Contribution

Carried out the statistical analysis and edited the final version of the manuscript AE, prepared the proposal and practically carried out the study. FN, prepared the paper, edited the final version of the manuscript and helped to carried out the study, EA, carried out the statistical analysis. MZ designed and supervised the study.

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