SCIENTIFIC ARTICLE

Bacterial colonization due to increased nurse workload in an intensive care unit

Ilker Onguc Aycan [a,*], **Mustafa Kemal Celen** [b], **Ayhan Yilmaz** [c], **Mehmet Selim Almaz** [d], **Tuba Dal** [e], **Yusuf Celik** [f], **Esef Bolat** [g]

[a] *Department of Anesthesiology and Reanimation, Dicle University Hospital, Diyarbakir, Turkey*
[b] *Department of Infection Diseases, Dicle University Hospital, Diyarbakir, Turkey*
[c] *Department of Anesthesiology and Reanimation, Women Health and Gynecological Hospital, Diyarbakir, Turkey*
[d] *Anesthesiology and Reanimation, Lice States Hospital, Diyarbakir, Turkey*
[e] *Department of Microbiology, Dicle University Hospital, Diyarbakir, Turkey*
[f] *Department of Biostatistic, Dicle University Hospital, Diyarbakir, Turkey*
[g] *Department of Anesthesiology and Reanimation, Bozok University Hospital, Yozgat, Turkey*

Abstract

Introduction: The rates of multiresistant bacteria colonization or infection (MRB+) development in intensive care units are very high. The aim of this study was to determine the possible association between the risk of development of nosocomial infections and increased daily nurse workload due to understaffing in intensive care unit.

Methods: We included 168 patients. Intensity of workload and applied procedures to patients were scored with the Project de Recherché en Nursing and the Omega scores, respectively. The criteria used for infections were those defined by the Centers for Disease Control.

Results: Of the 168 patients, 91 (54.2%) were female and 77 (45.8%) were male patients. The mean age of female and male was 64.9 ± 6.2 years and 63.1 ± 11.9 years, respectively. The mean duration of hospitalization in intensive care unit was 18.4 ± 6.1 days. Multiresistant bacteria were isolated from cultures of 39 (23.2%) patients. The development of MRB+ infection was correlated with length of stay, Omega 1, Omega 2, Omega 3, Total Omega, daily PRN, and Total PRN ($p < 0.05$). There was no correlation between development of MRB+ infection with gender, age and APACHE-II scores ($p > 0.05$).

Conclusion: The risk of nosocomial infection development in an intensive care unit is directly correlated with increased nurse workload, applied intervention, and length of stay. Under-staffing in the intensive care unit is an important health problem that especially affects care-needing patients. Nosocomial infection development has laid a heavy burden on the economy of many countries. To control nosocomial infection development in the intensive care unit, nurse workload, staffing level, and working conditions must be arranged.

© 2014 Sociedade Brasileira de Anestesiologia. Published by Elsevier Editora Ltda. All rights reserved.

* Corresponding author.
 E-mail: ilkeraycan@hotmail.com (I.O. Aycan).

Colonização bacteriana por causa do aumento da carga de trabalho da equipe de enfermagem em unidade de terapia intensiva

Resumo

Introdução: As taxas de desenvolvimento de infecção ou colonização por bactérias multirresistentes (BMR+) em unidades de terapia intensiva são muito elevadas. O objetivo deste estudo foi determinar a possível associação entre o risco de desenvolvimento de infecções hospitalares e o aumento da carga de trabalho diária da equipe de enfermagem devido à insuficiência de pessoal em unidade de terapia intensiva.

Métodos: Cento e sessenta e oito pacientes foram incluídos. O volume da carga de trabalho e os procedimentos realizados em pacientes foram avaliados com o uso de instrumentos de medidas como o Projeto de Pesquisa em Enfermagem (*Project de Recherché en Nursing*) e o Omega, respectivamente. Os critérios usados para definir infecções foram os definidos pelos Centros de Controle de Doenças.

Resultados: Dos 168 pacientes, 91 (54,2%) eram do sexo feminino e 77 (45,8%) do sexo masculino. As médias das idades de mulheres e homens foram $64,9 \pm 6,2$ e $63,1 \pm 11,9$ anos, respectivamente. A média do tempo de internação em unidade de terapia intensiva foi de $18,4 \pm 6,1$ dias. As bactérias multirresistentes foram isoladas a partir de culturas de 39 (23,2%) pacientes. O desenvolvimento de infecção por BMR+ foi correlacionado com tempo de internação, Omega 1, Omega 2, Omega 3, Omega total, PPE diário e PPE total ($p < 0,05$). Não houve correlação entre desenvolvimento de infecção por BMR+ e gênero, idade e escores no APACHE-II ($p > 0,05$).

Conclusão: O risco de desenvolvimento de infecção hospitalar em unidade de terapia intensiva está diretamente relacionado com o aumento da carga de trabalho de enfermagem, as intervenções praticadas e o tempo de internação. A falta de pessoal em unidade de terapia intensiva é um problema de saúde importante que afeta principalmente os pacientes que requerem cuidados. A infecção hospitalar colocou um fardo pesado sobre a economia de muitos países. Para controlar o desenvolvimento de infecção hospitalar em UTI, a carga de trabalho de enfermagem, a composição do pessoal e as condições de trabalho devem ser organizadas.

Introduction

Nosocomial infections (NIs) are commonly observed in intensive care units (ICUs). Recommended conducts to avoid and control the spread of NI have been published, including measures to make it as multiresistant bacteria (MRB).[1,2] NI have well-documented adverse effects on attributable mortality and morbidity, length of stay (LOS), and hospital costs. Fewer data are available on the effects of NI on workload of nurses. Most studies of extra costs related to personal charges based their cost estimates on the attributable excess of hospital LOS.[3–7] Although the increase in LOS associated with NI is an important provenance of extra costs, it fails to reflect the effects of NI on the daily workload of nurses and therefore is not enough for determining staffing requirements.

Evaluation of the effects of NI on nurse workload is difficult because the relation between these two parameters is complex. Understaffing and a compact nurse workload can be viewed as a risk factor for NI or as an effect of NI.

On one hand, excessive nurse workloads have been shown to contribute to recurrent NI outbreaks; moreover, in a certain patients, a persistently high level of therapeutic activity may be a risk factor for NI.[8–10] On the other hand, NI can increase the severity of illness in the patient, and consequently the level of therapeutic activity, and requires stepped-up infection control procedures, especially when the causative organism is an MRB, both adding to the nurse workload.[10] These aspects of the daily workload should be considered when the quest is to match staffing patterns to both the number of patients and the level of care in each patient. The scoring systems able of measuring these aspects are needed.

The aim of this study was to determine the possible association between the risk of development of NIs and increased daily nurse workload due to understaffing in ICU, and to find out the risk factors in development of MRB colonization in patients with and without MRB colonization using Omega score[10] and Project de Recherché en Nursing (PRN) systems.[11]

Methods

A retrospective study has been conducted in a 15-bed medical ICU in the General Intensive Care Unit of the Diyarbakir Memorial Hospital in Diyarbakir, Turkey, between October 1, 2012 and March 31, 2013. The study protocol

Table 1 The Omega scoring system.

Items	Points
Category 1	
Tracheotomy	6
Chest tubes	6
Training for home mechanical ventilation	6
Central venous catheter	3
Arterial line	3
Pulmonary artery catheter	6
Temporary cardiac pacing	3
Nasotracheal or orotracheal intubation	6
Cardioversion and defibrillation	3
Cardiac arrest	10
Vasoactive drug infusion	6
Fibrinolysis	10
Inrta-aortic balloon and counterpulsation	10
Infusions of blood products	10
Gastric lavage	1
Parenteral nutrition	6
Balloon tamponade of gastroesophageal varices	3
Enteral nutrition	3
Ascites reinstallation	10
Arteriovenous bypass	10
Ureteral catheter	3
Percutaneous cystostomy	1
Complex orthopedic traction	6
Neurological examination	1
Lumbar puncture	1
Intracranial pressure monitoring	3
Infusion of sedative drugs	6
Peritoneal lavage	3
Category 2	
Hemodialysis, extracorporeal circulation	10
Plasmapheresis	10
Bronchoscopy	3
Gastrointestinal endoscopy	3
Ultrasonography	3
Angiography	10
Scintigraphy	6
Intrahospital transport	3
Preparation for out-of-hospital transport	1
Preparation for and transport to the operating room	6
Category 3	
Continuous intensive care unit surveillance	4
Mechanical ventilation	10
Continuous hemofiltration	10
Peritoneal dialysis	10
Digestive fluid reinstallation	6
Complex surgical dressings	6
Isolation	10

Table 2 The Simplified PRN for intensive care unit patients.

Nursing categories	No. of tasks	No. of modalities
Mobilization	3	6
Elimination	3	8
Hygiene	2	4
Feeding	2	6
Communication	3	7
Respiration	3	8
Diagnosis	8	26
Treatments	11	22
Total	35	87

Modalities: in each nursing category, the weight of a given task may vary according to the number of times the task is performed each day and the number of nurses needed to perform the task.

Patients were separated into two groups, based on MRB colonization or infection. MRB colonization (MRB+ group) was defined as recovery of an MRB from any clinical site at admission or during the ICU stay. The criteria used for infections were those defined by the Centers for Disease Control. MRB are defined as microorganisms that are predominantly bacteria, that are resistant to one or more classes of antimicrobial agents (ceftazidime-resistant *Pseudomonas aeroginosa* and *Acinetobacter baumannii*, methicillin-resistant *Staphylococcus aureus*, methicillin-resistant *Staphylococcus* spp., vancomycin-resistant Enterococcus, and beta-lactam producing Enterobactericeae, etc.). NIs were monitored by a Nosocomial infection control team. Periodic screening cultures were performed on all patients at ICU admission and weekly thereafter. Consequently, it is unlikely that any episode of MRB colonization or infection were missed. The patients who were admitted to the ICU during the study period and who had negative tests for MRBs constituted the MRB (−) group.

For each patient, the following data were recorded: socio-demographic data, primary diagnosis, and dates of ICU admission and discharge. The severity of illness was evaluated based on the APACHE-II calculated during the first 24 h of ICU stay. Nurses work in two shifts – night and day shifts – generally in the ICU. Two nurses work in the day-time shift (between 8:00 AM and 4:00 PM) and one in the night-time shift (4:00 PM and 8:00 AM).

Therapeutic and nursing activity during the complete ICU stay was estimated using the Omega score and the PRN system. Moreover, we performed a specific functional analysis of recommended procedures for managing MRB nosocomial colonization or infection.

The Omega score is the therapeutic activity scale constituted of 45 items scored 1–10 and divided into three categories, as follows: category 1, tasks recorded only the first time they are carried out; category 2, tasks recorded each time they are carried out; category 3, tasks recorded each day they are carried out. The total score is calculated by adding the points in the three categories at ICU discharge (Table 1). The Simplified version for ICU is a specific scale for nurse workload evaluation. It includes eight categories of nursing procedures covering all technical, relational, and basic tasks (Table 2). In each category, nursing tasks are

was approved (14.07.2013/141) by the Ethical committee of Bozok University. All patients admitted to the ICU during the 6-month study period. 168 patients [91 (54.2%) female, 77 (45.8%) male] were included in the study.

Table 3 Primary diagnosis in the study population.

Diagnosis	Overall population	MRB (−)n (%)	MRB (+)n (%)
No. of patients (%)	168	129 (76.8)	39 (23.2)
Pneumonia	39 (23.2)	32 (82)	7 (18)
Cerebrovascular thromboembolus	28 (16.6)	22 (78.6)	6 (21.4)
Bacteriemia	23 (13.7)	19 (82.6)	4 (17.4)
Intracranial hemorrhage	19 (11.3)	15 (78.9)	4 (21.1)
Complicated urinary tract infections	13 (7.7)	8 (61.5)	5 (38.5)
Intraabdominal infection	11 (6.5)	10 (90.9)	1 (9.1)
Hemorrhagical infarct	9 (5.3)	8 (89.9)	1 (10.1)
VIP	7 (4.2)	3 (42.9)	4 (57.1)
Others	19 (11.3)	12 (63.2)	7 (36.8)

MRB, multiresistant bacterial colonization.

carefully individualized, described, and weighted. A fixed value is assigned to each task (one point is equal to 5 min). The time needed to complete each task rightly was determined by Delphi consensus. The times for routine infection control practices used in all patients are included in each task. Items are entered either daily or each time they are carried out.

Data management and analysis were done using SPSS 11.5 software (SPSS Inc., Chicago, IL, USA). Results were expressed as means ± standard deviations. Continuous variables in the two unmatched groups were compared using the unpaired Student's t test. For data that were not normally distributed, the nonparametric Mann–Whitney test was used. p values less than 0.05 were considered as significant.

Results

Of the 168 patients contained in the study 91 (54.2%) were female and 77 (45.8%) were male patients. The mean age of the female and male patients was 64.9 ± 6.2 years and 63.1 ± 11.9 years, respectively. The mean times of hospitalization period in ICU were 18.4 ± 6.1 days. The patient's primary diagnosis and indication for hospitalization are demonstrated in Table 3. For each patient, the screening tests and cultures of blood, urine, feces, and endotracheal tube were performed after admission to ICU and each week thereafter. In 39 (23.2%) cultures taken from the patients, MRB (+) were demonstrated (Table 3).

The mean time of LOS for MRB-colonized and MRB (−) patients in ICU was 22.3 ± 10.8 days and 14.2 ± 7.1 days, respectively. Thus the development of MRB colonization was correlated with LOS ($p = 0.001$).

Total Omega score was 21 ± 9.1 in the MRB-colonized patient group, while in MRB (−) patient group it was 10.3 ± 2.1 ($p = 0.003$). Total PRN score in MRB-colonized and MRB (−) patient group was found as 1519 ± 103 and 719 ± 52, respectively ($p = 0.012$).

The developments of MRB (+) colonization or infection in patients were correlated with LOS, Omega 2, Omega 3, Total Omega, daily PRN, and Total PRN ($p < 0.05$). There were no correlations between the development of MRB (+) infection with gender, age, and APACHE-II and Omega 1 scores ($p > 0.05$). In the PRN system, the comparison of the workload of nurses revealed that in the MRB colonized patient group the workload of nurses was significantly higher than the one in the MRB patient (−) group ($p < 0.001$) (Table 4).

PNR score consist of four parts that the nurse should practice:

1. Isolation of the patient
2. Cleaning with antiseptic solution
3. Changing bed covers
4. Collection of blood, urine and other specimens for culture

On the whole, the functional analysis showed that the amount of time needed each day to carry out MRB (−) driven

Table 4 Comparison between the MRB (−) and MRB (+) groups.

No. of patients	MRB (−)(n = 129)	MRB (+)(n = 39)	p
Age	63.1 ± 11.8	64 ± 9.4	0.078
APACHE-II	22 ± 8.9	24 ± 6.1	0.054
LOS (days)	14.2 ± 7.1	22.3 ± 10.8	0.013
Omega 1	3.5 ± 0.9	4.9 ± 1.6	0.081
Omega 2	6.1 ± 1.1	9.4 ± 4.2	0.022
Omega 3	0.9 ± 0.3	3.1 ± 2.1	0.009
Total Omega score	10.4 ± 1.2	17.2 ± 7.4	0.017
Total PRN score	719 ± 52	1519 ± 103	0.039
Daily PRN score	50 ± 3.4	68 ± 8.9	0.041

LOS, length of stay; MRB, multiresistant bacterial colonization; PRN, *Project de Recherché en Nursing*.

tasks was 88 min per patient. Most of the time was spent on isolation precautions and antiseptic baths. In our ICU, three nurses, two during the day time and one during the night, are on duty each day. The mean care time, nurses spent for MRB (−) patients, was 88 min, where as it was 62 min for MRB-colonized patients.

Discussion

To avoid high rates of nosocomial colonization or infections with resistant bacteria observed in ICUs, the mechanism of infection development should be investigated. Eradication of infection development seems reasonable than management of NI infections as NI development increases morbidity and mortality as well as LOS and increases the costs. The understaffing and increased workload of nurses is a factor that concomitantly increases the NI.

In literature there are few studies on the relationship between nurse workload and NI development. Many studies have determined that inclined LOS rather than staff salaries lay a heavy burden on the countries' economy. The appropriate number of nurses staffing in the ICU would reduce NI development and the costs in the longer term. Increased intensity of workload of the nurses and understaffing is also a risk factor for NI. Excess workload would cause delays in patient-care which results in an increase in development of hospital infections. Haley is the first one that emphasized on this topic. He had determined that staphylococcal epidemic in infants in the ICU is related to staff insufficiency. In another study Taunton et al. demonstrated a correlation between urinary tract and sepsis in emergency room and ICU with increased workload due to nurse's absenteeism without excuse.[12]

In a study which has been conducted on 177 patients during an eight months period,[13] interventions applied to these patients were evaluated with Omega 1, 2 and 3. As a result, the relationship between MRB (+) NI development and Omega 2, 3 and total Omega scores were found to be statistically significant ($p < 0.05$).[13] In our study we also used Omega score to assess treatment and intervention applied to patients. We found out that there was a statistically significant correlation between MRB (+) NI development and Omega 2, 3 and Total Omega ($p = 0.001$). Interventions applied to patients were found to be a risk factor for NI development.

Girou et al.[14] determined a relationship between NI development with LOS and inclined treatment activity. Treatment activity and treatment and intervention applied to patients were evaluated with Therapeutic Intervention Scoring System (TISS) and Omega score.

Fridkin showed that in central venous catheter-associated bloodstream infection risk is related to patient/nurse ratio.[15] In our study 26 (18.8%) of the 138 patients demonstrated MRB-colonization in neurology ICU related to increased nurse workload. Increase in NIs with MRB-colonization were related with the period of increased workload of nurses, elongated LOS and increased number of interventions.

PRN system is an effective activity in assessment of nurse workload. In his study Pittet demonstrated that during periods when the nurse workload increased or when there was understaffing of nurses, NI frequency was also increased.[16] There are many scoring systems for assessment of health staff workload. In our study we used PRN system. The staff nurses were listed. The duties for each patient were noted. In the PRN system, maximum care time for each patient in optimal circumstances was suggested to be up to 745 min.

Saulnier et al.[13] reported that mean care time for each patient was 245 min. In the same study, there was a statistically significant correlation between daily and Total PRN with MRB (+) NI development. It was seen that MRB (+) NI development increased while total and daily PRN incline. Likewise in our study there was direct correlation between total and daily PRN and MRB (+) NI development. During inclination period in PRN, MRB (+) NI development was increased too ($p = 0.001$). It was seen that as the nurse workload increased, the care period for each patient decreased.

Robert et al. examined nosocomial bloodstream infections in surgery intensive care related to increased nurse workload for a period of eight months. In this study, 28 patients with NI were compared with the data of control group composed of 90 patients who were hospitalized for more than 3 days in the same ICU. Elongated intravenous catheter usage, total parenteral support and declined nurse/patient ratio were found to be correlated with NI development.[17] Likewise, in our study, times of nurse understaffing in our ICU were correlated with increase in the risk of NI.

On the whole, the TISS and Omega scores assess the nurse workload associated with technical procedures and are sensitive to a possible increase in the severity of illness due to MRB NI. The PRN system, but not the TISS or the Omega, takes into account routine infection control procedures and basic care. These three tools underestimate the daily workload related to nursing procedures now recommended for MRB infected ICU patients. This workload can be assessed by a functional analysis of care, as illustrated in this study. The results may vary across units; in particular, they may be sensitive to study design and equipment.

As reported from the studies, in order to offer a high quality service in ICU, to reach an adequate nurse staffing level and a standard ratio of nurse/patient is mandatory. The role of nurse understaffing in nosocomial viral gastrointestinal infections on a general pediatrics ward nurse was evaluated in one study and determined that nurse absentees in a neonatal ICU may yield NI epidemics.[18] Similarly in another study in England, it has been demonstrated that the quality of service to care-needed patients was increased with inclined staffing levels and decline in nurse workload. Inclined staffing levels and decline in nurse workload would contribute in controlling NI.[19]

As a conclusion, the risk of NI development in ICU is directly correlated with increased nurse workload, applied intervention and LOS. Understaffing in ICU is an important health problem that especially affects care-needed patients. NI development laid a heavy burden on the countries' economy. To control NI development in ICU, nurse workload, staffing level and working conditions must be arranged. Unlike general bias, the major factors that increase health costs are NI and LOS rather then staff salaries.

Conflicts of interest

The authors declare no conflicts of interest.

References

1. Garner JS, the Hospital Infection Control Practices Advisory Committee. Guideline for isolation precautions in hospitals. Infect Control Hosp Epidemiol. 1996;24:24–52.
2. Hospital Infection Control Practices Advisory Committee (HICPAC). Recommendations for preventing the spread of vancomycin resistance. Infect Control Hosp Epidemiol. 1995;16:105–13.
3. Spengler RF, Greenough WB. Hospital costs and mortality attributed to nasocomial bacteremias. JAMA. 1978;240:2455–8.
4. Landry SL, Kaiser DL, Wenzel RP. Hospital stay and mortality attributed to noscomial enterococcal bacteremia: a controlled study. Am J Infect Control. 1989;17:323–9.
5. Durand-Zaleski I. Estimating the cost of intensive care. Intensive Care Med. 1994;20:538–9.
6. Coello R, Gleinster H, Fereres J, et al. The cost of infection in surgical patients: case–control study. J Hosp Infect. 1993;25:239–50.
7. Kappstein I, Schulgen G, Beyer U, et al. Prolongation of hospital stay and extra costs due to ventilator-associated pneumonia in an intensive care unit. Eur J Clin Microbiol Infect Dis. 1992;11:504–8.
8. Saulnier F, Grandbastien B, Poisson C, et al. Consequences de la multi-resistance bacterienne en Reanimation srla duree de sejour et la charge en soins. Rean Urg. 1997;6:213–22.
9. Haley RW, Cushion NB, Tenover FC, et al. Eradication of endemic methicilin-resistant *Staphylococcus aureus* infections from a neonatal intensive care unit. J Infect Dis. 1995;171:614–24.
10. Société de réanimation de la langue française. Score d'activité Oméga. Guide des Outils d'évaluation en Réanimation. Paris, France: Arnette; 1995. p. 39–44.
11. Saulnier F, Duhammel A, Descamps JM, et al. Indicateur simplifié de la chargeen soins spécifique a la réanimation: le PRN réa. Rean Urg. 1995;4:559–69.
12. Taunton RL, Kleinbeck SVM, Stafford R, et al. Patient outcomes. Are they linked to registered nurse absenteeism, separation, or workload? J Nurs Adm. 1994;24:48–54.
13. Saulnier F, Hubert H, Onimus T, et al. Assessing excess nurse work load generated by multiresistant nasocomial bacteria in intensive care. Infect Control Hosp Epidemiol. 2001;22:273–8.
14. Girou E, Stephan F, Novara A, et al. Risk factors and outcome of nosocomial infections: results of a matched case–control study of ICU patients. Am J Respir Crit Care Med. 1998;157:1151–8.
15. Fridkin SK, Pear SM, Williamson TH, et al. The role of under-staffing in central venous catheter-associated bloodstream infections. Infect Control Hosp Epidemiol. 1996;17:150–8.
16. Pittet D, Touveneau S, Paccaud U, et al. Infections acquises en reanimation et surcharge en soins. In: 7 eme Congress de l'Association Latine pour l'analyse des systemes de Sante. 1996. p. 301–4.
17. Robert J, Fridkin SK, Blumberg HM, et al. The influence of the composition of the nursing staff on primary bloodstream infection rates in a surgical intensive care unit. Infect Control Hosp Epidemiol. 2000;21:12–7.
18. Stegenga J, Bell E, Matlow A. The role of nurse understaffing in nosocomial viral gastrointestinal infections on a general pediatrics ward. Infect Control Hosp Epidemiol. 2002;23:133–6.
19. Hurst K. Relationships between patient dependency, nursing workload and quality. Int J Nurs Study. 2005;42:75–84.