Case Report

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Changing Medical ICU Environment and the Impact on Nosocomial Infection

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Nosocomial infections (NIs) are one of the most common complications that occur in ICU patients and confer an increased relative risk of 3.5 for mortality (1). These types of infections may affect from 5 to 35% of patients who are admitted to ICU's (2). Guidelines for Environmental Infection Control in Health-Care Facilities by the CDC, and the Healthcare Infection Control Practices Advisory Committee [HICPAC] guidelines (3) have become standard. These recommendations have been tested in clinical trials of routine infection control surveillance (4-6). Also, a revised policy for antimicrobial therapy has proved a reduction in ICU acquired infections and mortality (7). An extensive review of the principles of infection control in the ICU has been published elsewhere (8).

In a study by JL Vincent and co-workers (9) there was a 20.6% NIs prevalence was reported in the European Prevalence of Infection in Intensive Care Study (EPIC). This study included 10,038 patients from 1,417 European ICUs in 1992. The distribution of infections was reported to be the following: Pneumonia-respiratory tract (64.7%), UTI (17.6%), Bacteremia (12%). Additionally, it is widely accepted across the literature that developing NIs during ICU hospitalization increase the risks for longer ICU stay, lead to complications in 25 to 33% of those patients admitted to ICUs, increase health-care related costs, and increase risk for death.

Ever since the 1980s, the CDC has emphasized that at least one third of NIs are preventable through infection control programs (10). This agency has published guidelines to minimize the risk of transmission of infectious agents from colonized/infected patients to other patients or healthcare workers (11). The key elements to prevent nosocomial infection include epidemiologic surveillance and intervention, quality controls for medical equipment, administrative control for health-care personnel and patients, and engineering controls.

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Recently we underwent a relocation of our medical intensive care unit (MICU) within our hospital into a completely different geographical area as part of a facilities expansion project. In our study, we intended to investigate whether relocating a Medical Intensive Care Unit (MICU) and improving access and availability of infection control measures decrease the rate of NIs and mortality. We hypothesized that relocation of the MICU decreases the incidence of NIs, and may possibly have an impact on mortality.

Methods

Study Population and Design

We collected a database by a systematic electronic record review of admissions and transfer the patients into the MICU. Patients were organized into two (2) groups according to the MICU location, whether they were admitted or transferred to the unit. Group I included admissions and transfers into the prior MICU (old-MICU), and Group II included admissions and transfers into the newer one (new-MICU). The new-MICU was inaugurated in March 2004. The time frame study was as follows: Group I March 2003-February 2004, Group II March 2004-March 2005. Inclusion and exclusion criteria are detailed in **Table 1.**

TABLE 1. CRITERIA FOR ENROLLMENT

INCLUSION CRITERIA:

• All admissions and transfers into the corresponding MICUs within the stated dates.

EXCLUSION CRITERIA:

• Transfers from other ICUs, or other hospitals.

• Procedures performed or at other hospital institutions.

• Transfers into another unit within 24 hours.

• Insufficient data regarding infections: temperatures, cultures, imaging studies, identifi cation of culture sites.

• Patient died within the first 48 hours of admission to the MICUs.

The construction of a new-MICU in our institution was part of a project undertaken to increase admission capabilities to our patient population in view of a growing demand for ICU beds. The old-MICU was adapted for use of the Coronary Care Unit, which offers services to critically ill patients as well. **Table 2** summarizes the major differences between both MICUs.

TABLE 2. UNIT DESIGN DIFFERENCES

Infection Control Measures	Old-MICU	New-MICU
Hand-rub station	Loose bottles	Fixed on wall between each bed
Barriers	Removable curtains	Solid walls
Hand washing station	2 stations	5 stations
Nurse station	1 station	2 stations
Total number of bed/isolation	10/2	12/2
Square feet available/bed	75 ft.	145 ft.

In order to control the nature and the quality of the measurements, defined criteria and definition of nosocomial infection were adopted from the currently accepted clinical parameters for infections (12-17). Our data differ from the data obtained by the infection control department that uses attack rates. Our definition of infection is based on a clinical syndrome rather than development of positive culture.

Transferred patients must have spent more than 24 hours in a ward outside MICU to be considered transfer. Primary admission diagnosis and APACHE Score were analyzed.

Presence of infection at time of admission and the clinical or microbiological evidence were reviewed, and correlated to a history of prior NIs (defined at 1 month prior to the studied admission). Length of stay in MICU was defined as 24-hour days spent in MICU. MICU survival was defined as survival at 48 hours after transferred out of MICU into a non-ICU ward. The 28-day survival was defined as survival 28 days after transferred out of the MICU. The primary outcomes measures were the difference between both Units in development of NIs, and the impact of NIs to survival in the studied group of patients.

Statistical Analysis

The statistical design used for this study was a retrospective cohort based on medical record reviews and followed over time during the assigned twelve months corresponding to both groups. Data provided by the infectious control department (18) in our institution showed attack rates [Attack Rate= infected subjects/total subjects at risk] for NIs observed in the old-MICU was 18.5%, and the attack rate for the new-MICU was 5.32%. To maximize the chance of observing an association between the predictor and outcome variables, a power of 90% (β =0.10) was used in the sample size determination. Based on the last two-year history of MICU NIs attack rate, a minimum sample size of 300 patients (150 for the old-MICU and 150 for the new-MICU) was established. At the end of the data collection process, 278 records were collected. However, 50 subjects did not fulfill the established inclusion/exclusion criteria, resulting in a total of 228 subjects (82.0% of the sample collected). All statistical analyses were performed using a significance level of 95% (α =0.05) and univariate and bivariate analyses were carried out.

Results

Descriptive Data

The mean age of the 228 patient reviewed was 70.8±11.3 years, ranging from 22 to 91 year of age. Sex distribution was males (97.2%) and only 6 were females (2.8%). This is compatible and represents the population in our Veterans Health facility. Out of the total population analyzed 89% (n=171) survived beyond 28 days post discharge from ICU.

The total amount of patients admitted to the new-MICU is explained by the availability of two more beds in new-MICU making it capable of accommodating a larger number of direct admissions from the emergency room. In the old-MICU transfers from ill patients in medical wards was the predominant situation as it had fewer beds and could not receive direct emergency room admissions on a regular basis. **Table 3** shows the exact figures.

TABLE 3. UNIT CENSUS DISTRIBUTION

Unit	Admissions	Transfers	Total Patients
Old-MICU	171	418	589
New-MICU	449	330	779

Clinical Data

APACHE-II scores ranged from 7 to 43, mean 17.8±6.3 amongst all the cases. The APACHE-II did not differ significantly between the old and new-MICU (18.2 vs. 17.5; p =0.444). There was no significant difference between the groups in terms of the requirement for vasopressors, and admission diagnosis. Ventilator associated pneumonia was the most common NIs noted in both groups. The distribution of the types of NIs is shown in **Table 4**. Overall mean length of stay (LOS) differed between both groups: old-MICU 8 days vs. 4.6 days in the new-MICU (p =0.004); yet there was no difference in LOS once the patient developed a NI (old-MICU 18.8 days vs. new-MICU 17.7; p =0.47).

TABLE 4. TYPES OF NOSOCOMIAL INFECTION AND CORRESPONDING MORTALITY IN OVERALL MORTALITY

Infection Type*	N (% NIs)	% Mortality
Ventilator Associated Pneumonia	16 (7.4)	62.5
Urinary Tract Infection	6 (2.8)	66.7
Pneumonia	4 (1.8)	100
Colitis	2 (0.9)	50
Catheter Related Infection	7 (3.2)	42.9
Bacteremia	5 (2.3)	80
Other	1 (0.5)	0

Primary outcome of changes in percentage of development of NIs between both study groups, we found a significant decline in NIs in the new-MICU (**Figure 1**).

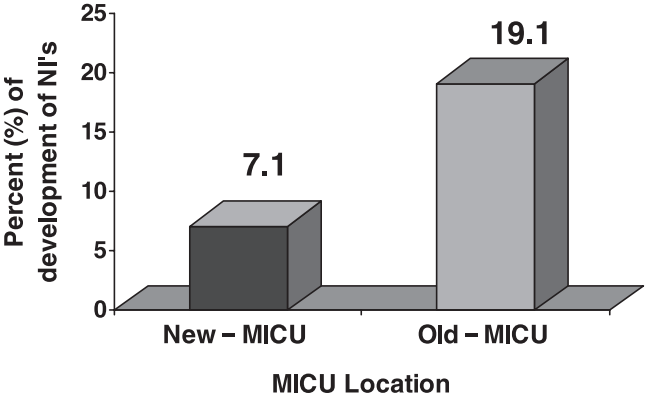

Figure 1. Development of NIs according to MICU location

In order to determine the relationship between the MICU location and the development of nosocomial infections, a chi-square and a relative risk were calculated. The association between the MICU location and the development of a nosocomial infection was statistically significant ($p < 0.008$); the new ICU subjects showed a 48.8% less probability of develop a nosocomial infection compared to the old ICU subjects. Relative risk 0.4 (95% CI; 0.2–0.8)

The relative risk estimates showed that subjects in the old-MICU had 1.6 times the risk of the new-MICU people in of dying before ICU discharge or 28 days later ($p > 0.065$). Although not statistically significant, this difference may be considered clinically significant. Survival to ICU was also analyzed to see if there was a difference in survival irrespective if whether patients developed a NI.

We analyzed the difference in development of NIs from the patients admitted due to cardiovascular causes. This analysis was done because many of the cardiovascular patients admitted to our MICU have a short stay, and carry a lower attack rate as compared to non-cardiac patients. There was a significant reduction in composite mortality (death while in ICU, and at 28-day after ICU discharge) when excluding the patients who have been hospitalized due to acute cardiac illness (**Figure 2**).

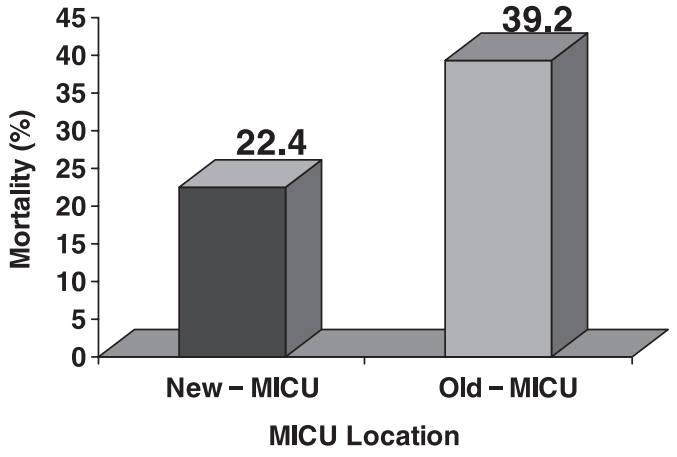

Figure 2. Overall mortality by MICU location in non-cardiac patients.

There was a significant reduction in composite mortality (death while in ICU, and at 28-day after ICU discharge) when excluding the patients who have been hospitalized due to acute cardiac illness. $p = 0.026$

There was no difference in the development of NIs upon comparing only cardiovascular patients between both groups (old-MICU 2 patients (5.9%) vs. new-MICU 1 patient (3.1%); $p = 1.000$, RR 0.7, 95% CI). Multiple logistic regression analysis of patient's mortality adjusted by development of ICU infection and location shows a significant reduction in mortality in the new-MICU related to lower rate of nosocomial infection (**Table 5**).

TABLE 5 MULTIPLE LOGISTIC REGRESSION ANALYSIS OF PATIENTS THAT DEVELOPED ICU INFECTION ADJUSTED BY MICU LOCATION AND CARDIOVASCULAR PATIENTS.

Independent variable	Regression coefficients	RR	*p* value
MICU location	-1.320	0.267	0.005
Cardiac	1.519	4.569	0.017
Constant	2.391	10.928	0.000

In terms of survival after the development of NIs, there was absolutely no difference between both MICUs (42.9% for each location; $p = 1.00$).

Discussion

Our data suggest that relocating a medical ICU to a new state of the art facility, with increased infection control measures, results in effectively decreasing the risk for NIs. Moreover, this decrease in NIs may translate into improved clinical outcomes. It is very important to note that both units studied had exactly the same clinical directors, department heads of medical and ancillary-services, nursing-patient ration, and medical standards.

Also, only a sample of the patient population was sampled in this analysis. We would expect this effect on mortality to be amplified if this study was done examining all the admissions and transfers into the unit. Our study was only powered to detect a difference in development on NIs.

Attack-rates are the classical epidemiologic tools used to measure NIs in the ICUs. This measurement only examines the positive culture and is not sensitive to clinical scenarios of infections commonly seen in ICUs which often call for empirical therapy, and infectious diagnosis are made even in the eventuality of negative cultures. Our study differs in that we used clinical assessments and infections syndromes as the events to be analyzed. Moreover, our results show that once a patient develops a NI, the mortality is the same, irrespective of the infection control measures. This result clearly indicates that prevention of NI is a key treatment issue. Therefore, our data have clinical implications, and suggest that increase efforts should be made continuously to avoid NIs, and should be considered as part of the treatment of ICU patients.

This study is part of the body of evidence that justifies the need for combined staffing for optimization of infection control (19). Our data suggest that physical design of a MICU can be an integral part of infection control measures. Therefore, MICU expansions and locations are to be viewed as a priority and may be integrated fully into the continuous process of improvement of the quality of care.

Several studies have found that re-structuring, careful and innovative planning and design of a new ICU minimize the risk of hospital-acquired infection, and improve overall patient outcome (20,21). Yet none of these studies has specifically analyzed the effect of moving a MICU to a different location as having an impact on NIs and related mortality.

In a study by Hartenauer U *et al.*, a group of nearly 1,000 patients was surveyed for development of NIs in a combined retrospective and prospective trial in a surgical ICU, which underwent relocation. The frequency of NIs was not affected by the different building constructions. This finding is in contrast with our results, yet the prospective arm of the study by Hartenauer followed patients for four years prospectively. How the effect of location seen in our data persists over time is also a matter, which warrants further research. This decrease in mortality is transitory remains a debatable issue.

Our study has its limitation. The data analyzed in this project only includes retrospective record reviews of a perhaps limited amount of subjects. What would be the result if all records were analyzed is debatable. This calls for using this study as pilot data for re-analyzing this issue in other similar ICUs. The tool used compare the severity of illness in the populations in both MICU units was the APACHE score. Yet this tool may not be sensitive to detect the clinical complications inherent to being in a medical ward prior to MICU admission, as compared to direct emergency room admissions. Therefore how comparable are the populations studied is debatable. In addition, the population attended in our hospital limits our demographics distribution. How this data may apply to other ICUs (e.g. neurosurgical, surgical, pediatric ICUs) still remains inconclusive.

It is difficult to generalize about which specific infection control interventions will and what will not work in a particular ICU. In an era were financial concerns in health-care is growing there will be limits for major multi-million investments in relocating an ICU. Whether an investing in a new ICU in a different geographical location within a hospital to reduce mortality is beyond the scope of this study, and therefore we cannot categorically recommend this major investment should be done. However, in general, careful consideration and good planning are excellent investments in the future success of a design for a new ICU or a facility renovation.

To conclude, our study demonstrated that changing a MICU to a newly constructed and geographically relocated, with optimal infection control measures, might result in a decreased incidence of NIs. This decrease in NIs is associated to a decrease in relative risk of mortality in clinically comparable populations. The effect of decreased mortality and length of stay is absent once a patient develops a NIs irrespective of the environmental conditions in the MICU.

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