Association Between ICU Admission During Morning Rounds and Mortality

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Background: No previous study has evaluated the association between admission to ICUs during round time and patient outcome. The objective of this study was to determine the association between round-time ICU admission and patient outcome.

Methods: This retrospective study included 49,844 patients admitted from October 1994 to December 2007 to four ICUs (two surgical, one medical, and one multispecialty) of an academic medical center. Of these patients, 3,580 were admitted to the ICU during round time (8:00 AM to 10:59 AM) and 46,264 were admitted during nonround time (from 1:00 PM to 6:00 AM). The medical ICU had 24-h/7-day per week intensivist coverage during the last 2 years of the study. We compared the baseline characteristics and outcome of patients admitted to the ICU between the two groups. Data were abstracted from the acute physiology and chronic health evaluation (APACHE) III database.

Results: The round-time and non-round-groups were similar in gender, ethnicity, and age. The predicted hospital mortality rate of the round time group was higher (17.4% vs 12.3% predicted, respectively; $p < 0.001$). The hospital length of stay was similar between the two groups. The round-time group had a higher hospital mortality rate (16.2% vs 8.8%, respectively; $p < 0.001$). Most of the round-time ICU admissions and deaths occurred in the medical ICU. Round-time admission was an independent risk factor for hospital death (odds ratio, 1.321; 95% CI, 1.178 to 1.481). This independent association was present for the whole study period except for the last 2 years.

Conclusions: Patients admitted to the ICU during morning rounds have higher severity of illness and mortality rates. (CHEST 2009; 136:1489–1495)

Abbreviations: APACHE = acute physiology and chronic health evaluation; OR = odds ratio; SMR = standardized mortality ratio

Intensivists in academic medical centers have responsibilities to provide good patient care and housestaff education. The Accreditation Council for Graduate Medical Education mandates regularly scheduled and formally conducted patient-based teaching rounds and daily management rounds.¹ Recognizing the importance of bedside rounds in graduate medical education, some educators have increased the time that faculty members spend at the

patient bedside.² Since the Institute of Medicine highlighted patient-centered care as one of the six quality domains in the *Crossing the Quality Chasm*:

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A New Health System for the Twenty-First Century,³ the role of patients and their families as passive observers has changed. This change has led to the

Manuscript received March 3, 2009; revision accepted May 8, 2009.

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Funding/Support: This project was supported by the Office of Faculty Development, Department of Medicine, Mayo Clinic (Rochester, MN) and by grant 1 UL1 RR024150 from the National Center for Research Resources, which is a component

of the National Institutes of Health, and the National Institutes of Health Roadmap for Medical Research.

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DOI: 10.1378/chest.09-0529

inclusion of patients and families during bedside rounds, potentially prolonging the duration of the rounds.⁴

Residents and fellows provide the bulk of patient care in teaching institutions. However, their inexperience and the effects of patient-based teaching on workflow may compromise patient care. Previous studies^{5,6} have shown no differences in the outcome of ICU patients treated at the beginning and during later periods of the academic year. This finding suggested that appropriate supervision and multidisciplinary teamwork in teaching institutions may minimize the risk associated with adding inexperienced providers to the care team.

Despite some disagreement about the exact time, there has been a consensus about the “golden hour” in trauma patients, highlighting the importance of correcting physiologic derangements early to reduce morbidity and mortality.⁷ Timely intervention improves the outcome of patients with nontrauma life-threatening illnesses⁸ including sepsis,⁹ stroke,^{10,11} cardiac arrest,^{12,13} and acute myocardial infarction.^{14,15} Yet, because of the focus on rounds, critically ill patients admitted to ICUs during rounds may not get timely care, resulting in poor outcome. We undertook this study to determine the association between patient admission to the ICU during morning rounds and outcome.

MATERIALS AND METHODS

To monitor patient outcome and quality of care, four adult ICUs at our institution have used the acute physiology and chronic health evaluation (APACHE) III prognostic system since October 1994.¹⁶ This retrospective study involves the analysis of APACHE III data that were prospectively collected at the Mayo Medical Center (Rochester, MN) from October 1994 through December 2007. The study was approved by the Institutional Review Board. The Mayo Medical Center is a tertiary teaching institution with two hospitals comprising approximately 1,900 inpatient beds. Of the four study ICUs, one was a medical ICU, one was a multispecialty medical-surgical ICU, and two were surgical ICUs. Patients who did not authorize a review of their medical records for research and were admitted to an intermediate care area were excluded from the study. Only data from the first ICU admission of each patient were included for analyses. The “round-time admission group” included patients admitted to the ICU between 8:00 AM and 10:59 AM because teaching and patient care multidisciplinary rounds were usually made during that time. The non-round-time group included patients admitted to the ICU between 1:00 PM and 5:59 AM. Because of the potential overlap between the two study groups, we excluded patients who had been admitted to the ICU between 6:00 AM and 7:59 AM or between 11:00 AM and 12:59 PM.

Each ICU was staffed by critical care service teams consisting of attending intensivists, critical care fellows, residents, students, pharmacists, nurses, and respiratory therapists. The medical ICU physician staffing was changed from one-team to two-team coverage, on call on alternate days, starting in April 2002.¹⁷

Twenty-four-hour in-house intensivist coverage was started in the medical ICU in January 2006¹⁸ and in one surgical ICU in January 2007. The rapid response team for the regular hospital ward was started in one of the two hospitals in February 2006.

We used proprietary software (Cerner Corporation; Kansas City, MO) to retrieve data including age, ethnicity, gender, ICU admission source, ICU admission time, postoperative status at ICU admission, admission day intensity of treatment, the first ICU day APACHE III score, and predicted hospital mortality.¹⁹ The primary outcome measure was hospital mortality. The secondary outcome measures were ICU mortality and ICU and hospital lengths of stay. The ICU admission source was classified as operating room/recovery room, ED/direct admissions, transfer from other floors of the same hospital, and transfer from other institutions.⁶ All ICU admissions were categorized into three groups based on the intensity of treatment as follows: active treatment; high-risk monitor; and low-risk monitor.^{19–23}

Descriptive data are summarized as the mean (SD), median (interquartile range), or count (%). We used a χ^2 test to compare categorical variables, and we used the Student's *t* test and Wilcoxon rank sum tests to compare continuous variables. A customized multiple variable logistic regression model consisting of hospital mortality as a dependent variable, and admission source, APACHE III predicted mortality, and intensity of treatment as independent variables was created based on a previous analysis that identified the variables independently associated with hospital mortality in our patient population.⁶ We used Hosmer-Lemeshow statistic and the area under the receiver operating characteristic curve to assess the calibration and discrimination of the model. We used the logistic regression equation derived from this model to calculate the customized predicted probability of hospital death for each patient. Differences in mortality rates were expressed as the odds ratio (OR) for death with 95% CIs. The standardized mortality ratio (SMR) was defined as the ratio of the observed to the customized predicted mortality rate. We did not include the admission source in the multiple variable logistic regression model for the postoperative subgroup analysis since almost all were admitted from the recovery/operating rooms. All statistical analyses, except SMR, were performed using a statistical software package (SPSS, version 16.0 for Windows; SPSS Inc; Chicago, IL). SMR (95% CI) was calculated by using another software package (Confidence Interval Analysis, version 2.1.2; Trevor Bryant, University of Southampton; Southampton, UK). All statistical tests were two sided, and a *p* value of < 0.05 was considered statistically significant.

RESULTS

Excluding 2,291 admissions for lack of research authorization, 5,992 admissions for admission to the intermediate care area, 5,944 admissions because they were repeat admissions, and 6,244 admissions because they were patients admitted to the ICU between 6:00 AM and 7:59 AM or 11:00 AM and 12:59 PM, 49,844 of 70,315 admissions in the APACHE III database were included in the study. Of the study patients, 3,580 (7.2%) were admitted during round time. Patients in the round-time group were more likely to have a higher severity of illness and were less likely to be postoperative (Table 1). Round-time admissions accounted for 850 of the 22,904 total admissions (3.7%) in surgical ICU compared with 1,038 of 10,941 (9.5%) in the mixed ICU

Table 1—Baseline Characteristics of the Study Patients

Baseline Characteristics	Round-Time Patients (n = 3,580)	Non-Round-Time Patients (n = 46,264)	p Value
Male gender*†	1,970 (55.0)	25,857 (55.9)	0.20
White race*†	3,284 (91.7)	42,900 (92.7)	0.30
Age, yr‡	62.3 (18.2)	62.3 (17.5)	0.96
APS†	35 (22–52)	31.0 (21–47)	< 0.001
APACHE III score, median (IQR)†	50 (35–68)	45.0 (31–62)	< 0.001
APACHE III predicted mortality, %†			
Median (IQR)	7.78 (2.52–23.24)	4.50 (1.61–13.81)	< 0.001
Mean (SD)	17.4 (22.1)	12.3 (18.5)	< 0.001
Postoperative admission*	576 (16.1)	23,633 (51.1)	< 0.001
Admission intensity of treatment*			< 0.001
Low-risk monitor	879 (24.6)	16,271 (35.2)	
High-risk monitor	596 (16.6)	5,145 (11.1)	
Active	2,105 (58.8)	24,848 (53.7)	
Admission source*			< 0.001
Recovery/operating rooms	563 (15.7)	23,714 (51.3)	
ED/direct admission	1,221 (34.1)	12,335 (26.7)	
Same hospital	1,636 (45.7)	8,395 (18.1)	
Other hospital	160 (4.5)	1,820 (3.9)	
Admission ICU*			< 0.001
Medical	1,692 (47.3)	14,307 (30.9)	
Multispecialty	1,038 (29.0)	9,903 (21.4)	
Surgical	850 (23.7)	22,054 (47.7)	

APS = acute physiology score.

*Values are given as No. (%).

†Missing data: gender of 32 patients; 553 APACHE severity values; and ethnicity of 228 patients.

‡Values are given as the mean (SD).

and 1,692 of 15,999 (10.6%) in the medical ICU ($p < 0.001$). The medical ICU accounted for 32.1% of the total and 47.3% of the round-time admissions, and for 51.5% of the total and 55.2% of the round-time deaths.

The ICU and hospital mortality rates were higher for the round-time group (Table 2). Round-time admission was an independent risk factor for hospital mortality (Tables 3, 4). The area under the receiver operating characteristic curve (95% CI) of the multiple logistic regression model for predicting hospital mortality was 0.865 (0.860 to 0.871) and the Hosmer-Lemeshow statistic was 184.1 with a

p value of < 0.001 . Of the postoperative admissions, 390 of the patients in the round-time group (67.7%) had elective surgery compared with 80% of those in the non-round-time group ($p < 0.001$). Adjustment for the type of surgery (elective or emergency) did not change the independent association between round-time admission and hospital mortality in the postoperative patients. The adjusted ORs of round-time admission for hospital death were 1.34 (95% CI, 1.15 to 1.56; $p < 0.001$), 1.24 (95% CI, 1.00 to 1.53; $p = 0.051$), and 1.42 (95% CI, 1.07 to 1.88; $p = 0.016$), respectively, for the medical, multispecialty, and surgical ICUs.

Table 2—Mortality and Length of Stay Differences Between Round and Nonround Time Admissions

Outcome Measures	Round-Time Patients (n = 3,580)	Non-Round-Time Patients (n = 46,264)	p Value
ICU mortality*			
All	357 (10.0)	2,247 (4.9)	< 0.001
Postoperative	16 (2.8)	367 (1.6)	0.03
Non-postoperative	341 (11.4)	1,880 (8.3)	< 0.001
Hospital mortality*			
All	580 (16.2)	4,056 (8.8)	< 0.001
Postoperative	32 (5.6)	763 (3.2)	0.003
Non-postoperative	548 (18.2)	3,293 (14.6)	< 0.001
ICU length of stay, d†	2.0 (2.0–4.0)	2.0 (2.0–4.0)	0.42
Hospital length of stay, d†	8 (4–15)	7 (4–13)	0.07

*Values are given as No. (%).

†Values are given as the median (interquartile range).

Table 3—Multiple Variable Logistic Regression Analysis Showing the Association of Hospital Death With APACHE III Predicted Mortality Rate, Admission Source, Intensity of Treatment, and Round-Time/Non-Round-Time Admission

Predictor Variables	OR (95% CI)	p Value
Admission time		< 0.001
Nonround	1	
Round	1.321 (1.178–1.481)	
Predicted hospital mortality rate, %	1.050 (1.048–1.051)	< 0.001
Admission source		
Recovery/operating rooms	1	
ED/direct admission	1.740 (1.573–1.924)	< 0.001
Same hospital	2.352 (2.122–2.607)	< 0.001
Other hospital	1.702 (1.450–1.998)	< 0.001
Intensity of treatment		
Low-risk monitor	1	
High-risk monitor	1.723 (1.490–1.992)	< 0.001
Active	2.180 (1.933–2.459)	< 0.001

The mortality rates of the round-time vs non-round-time groups were 18.9% vs 14.5% ($p < 0.001$), 17.1% vs 10.3% ($p < 0.001$), and 9.8% vs 4.4% ($p < 0.001$), respectively, for medical, multispecialty, and surgical ICU admissions. Both the observed and customized predicted mortality rates of the round-time admissions were higher than those of the non-round-time admissions during all periods of the study (Table 5). Except for the last 2 years of the study, the SMR of the

Table 4—Multiple Variable Logistic Regression Analysis Showing the Association of Hospital Death With APACHE III Predicted Mortality Rate, Intensity of Treatment, and Round-Time/Non-Round-Time Admission in Postoperative and Non-Postoperative Subgroups

Predictor Variables	OR (95% CI)	p Value
Postoperative admissions		
Round-time admission	1.545 (1.029–2.320)	0.04
Predicted hospital mortality rate, %	1.067 (1.062–1.071)	< 0.001
Intensity of treatment		
Low-risk monitor	1	
High-risk monitor	1.830 (1.182–2.831)	0.007
Active	1.885 (1.556–2.283)	< 0.001
Non-postoperative admissions		
Round-time admission	1.289 (1.146–1.450)	< 0.001
Predicted hospital mortality rate, %	1.047 (1.045–1.048)	< 0.001
Intensity of treatment		
Low-risk monitor	1	
High-risk monitor	1.698 (1.430–2.016)	< 0.001
Active	2.231 (1.908–2.610)	< 0.001
Admission source		
ED/direct admission	1	
Same hospital	1.381 (1.268–1.505)	< 0.001
Other hospital	1.006 (0.867–1.167)	0.93

round-time admissions was higher (Table 5). Only the SMR of the 1996/1997 round-time admissions was different from 1.

Of the 15,999 medical ICU patients, 8,924 (55.8%), 3,996 (23.1%), and 3543 (22.1%), respectively, were admitted after initiating two-team physician staffing, and nighttime coverage by an in-house intensivist and a rapid response team. The differences in mortality rates between the round-time and non-round-time admissions during these different periods are summarized in Table 6.

DISCUSSION

In this study, we found ICU admission during morning rounds was associated with an increased severity-adjusted mortality rate in both postoperative and non-postoperative admissions. Patients admitted to the ICU during round time had higher severity of illness, and were more likely to be non-postoperative patients and transfers from regular wards in the same hospital. The medical ICU accounted for the highest number of deaths and round-time admissions. The association between round-time admission and increased mortality declined over time.

Although there have been fears that the patient care provided in July may be suboptimal, previous studies^{5,6} have shown this not to be the case. In academic ICUs, residents and fellows provide most of the care to critically ill patients at nights and on weekends. Despite staffing variations, several studies^{24–29} have shown no association between mortality and ICU admission at night or during the weekend. In the ICUs of teaching institutions, patient care is sometimes interrupted by didactic sessions and rounds. Teaching and work rounds usually occur at fixed times of the day. Bedside rounds may include going from one patient bed to the next, not from the sickest patient to the least sick. This approach may result in delayed resuscitation of critically ill patients admitted to the ICU during rounds, providing a potential explanation for the increased mortality we observed in this study.

We observed that patients admitted to the ICU during round time had higher severity of illness and were more likely to come from the ED or the same hospital ward compared with the majority of patients admitted from the recovery or operating rooms during nonround times. Attending-led rounds are usually performed between 8 AM and 11:00 AM in the regular hospital wards. Most of the patient care in the regular wards is provided by residents at night, without direct supervision by fellows or attending physicians. This absence of attending supervision and participation in patient care at night may have

Table 5—Differences in Observed and Predicted Mortality Rates Between Round and Nonround Groups at Various Times of the Study Period

Year Range	Round Time			Nonround Time		
	Observed Mortality Rate, %	Customized Predicted Mortality Rate, %	SMR (95% CI)	Observed Mortality Rate, %	Customized Predicted Mortality Rate, %	SMR (95% CI)
1994–1995	21.3	13.7	1.55 (0.95–2.40)	5.8	6.1	0.95 (0.81–1.12)
1996–1997	15.6	11.1	1.40 (1.07–1.80)	7.0	7.2	0.97 (0.88–1.06)
1998–1999	19.2	15.7	1.22 (0.99–1.50)	9.1	9.3	0.98 (0.90–1.06)
2000–2001	17.6	14.7	1.20 (0.97–1.46)	9.6	9.8	0.98 (0.91–1.05)
2002–2003	17.4	15.1	1.15 (0.95–1.38)	9.6	9.8	0.98 (0.91–1.05)
2004–2005	14.4	12.7	1.13 (0.91–1.38)	8.7	8.8	0.99 (0.91–1.07)
2006–2007	13.6	13.8	0.99 (0.81–1.20)	9.4	9.4	1.00 (0.93–1.08)

led to underrecognition of the patients' critical illness, delaying their transfer to the ICU. The increased risk of death probably reflects the higher adverse impact of delaying ICU care on the outcome of patients with higher severity of illness. However, because we do not have the data to confirm this, our assumption about the delay of care is based on mere speculation. The illness severity of the round-time admissions appeared to be higher in postoperative patients as well. The round-time admissions included a higher proportion of patients with emergency surgery compared with the nonround admissions, suggesting more difficult and complicated surgical cases, and patients who had operations during the night. We recognize that the high risk of death associated with round-time admission may have been due to inadequate adjustment for the complexity of the admissions.

In the current study, the SMR of the round-time group was higher than that of the nonround group, except for the last 2 years. However, there was a trend over time toward lower SMR. Most of the round-time admissions and deaths occurred in the medical ICU. We started a two-team physician coverage in 2002,¹⁷ and a 24-h in-house attending physician coverage during the last 2 years of the study in the medical ICU¹⁸ and in one of the surgical ICUs in 2007. The ICU physician-led rapid response team was available to cover emergencies in the wards of one of the hospitals during the last 2 years. We

speculate that the ICU staffing changes and the rapid response team may explain the relatively low SMR for the round-time group during the later period. The development of the rapid response team enables the nursing and junior physician staff to recognize the early signs of critical illness in the regular hospital ward and empowers them to transfer such patients to the ICU for early intervention. The 24-h presence of the attending physicians in the ICU may have lessened the workload during morning rounds, making the physicians available to manage newly admitted patients. It also provides additional support for the rapid response team, facilitating early recognition of critical conditions and appropriate and timely intervention.

Teaching and management rounds are prerequisites for graduate medical education. In addition to its educational benefits, well-planned and well-organized multidisciplinary rounds have been shown to improve the quality of care in hospital wards.³⁰ We are not aware of any previous studies addressing the association of round-time ICU admission with patient outcome. We believe organized and efficient rounds can be performed in the ICU without compromising patient care. To partly address round-related issues, we have created a new responsibility for one of the critical care fellows. In October 2008, we started assigning one critical care fellow dedicated to provide emergency care in the medical ICU and to support the rapid response team in the regular ward,

Table 6—Comparison of Mortality Rates in the Medical ICU Before and After Initiation of Two-Physician Teams, Nighttime Intensivist Coverage, and Rapid Response Team

Study Period	Round-Time Mortality (%)	Non-Round-Time Mortality (%)	p Value
One-physician team	145/702 (20.7)	930/6,373 (14.6)	< 0.001
Two-physician team	175/990 (17.7)	1,139/7,934 (14.4)	0.005
No in-house intensivist at night	267/1,308 (20.4)	1,621/10,995 (14.7)	< 0.001
In-house intensivist at night	53/384 (13.8)	448/3,312 (13.5)	0.881
Before rapid response team	272/1,331 (20.4)	1,638/11,125 (14.7)	< 0.001
After rapid response team	48/361 (13.3)	431/3,182 (13.5)	0.896

without any other competing responsibilities. In institutions that do not have the extra fellows or other physicians, physician extenders and flexibility and customization of the timing and structure of the rounds may provide alternative solutions.

Our study has several limitations. Since it was a single-center ICU study, the findings may not apply to other medical centers or non-ICU settings. Because the study was based on the APACHE III database, our data were limited to the data that were available in the database. Our multiple logistic regression model may not have included all prognostically important predictor variables. APACHE III scores are calculated based on the worst physiologic values within 24 h of ICU admission. Since APACHE III-based risk stratification is not calculated based on values available before ICU admission, it may not reflect the real baseline characteristics. Rounds usually occurred between 8:00 AM and 11:00 AM in the study ICUs. However, there may have been variations of timing rounds during the study period. Although the discrimination of our multiple logistic regression model for mortality prediction was good, its calibration was poor. The large sample size may explain the poor calibration.³¹ Most importantly, our data cannot be used to claim a cause-effect relationship between round-time admission and increased mortality because of the study design and the complexity of the round-time admissions.

In summary, this study shows that the conditions of the patients admitted to the ICU during morning rounds are more complex, and have higher severity of illness and hospital mortality rate compared with patients admitted during nonround times. Our study also showed that the risk-adjusted mortality rate was reduced when the care model was modified to match the complexity and severity of patient admissions. We believe that awareness of such risks and contributing factors with customized modification of rounds and care model may improve patient outcome. Based on such data, our critical care service is planning to have a senior critical care fellow dedicated to address the emergent needs of critically ill patients in the medical ICU and hospital wards during round times.

ACKNOWLEDGMENTS

Author contributions: Dr. Afessa contributed to the conception and design of the study, and acquisition as well as analysis and interpretation of data; drafted the submitted article and revised it; and approved the final submitted version. Dr. Gajic contributed to the conception and design of the study, and acquisition as well as analysis and interpretation of data; participated in revising the article; and approved the final submitted version. Dr. Morales contributed to the conception and design of the study, and interpretation of data; participated in revising the article; and

approved the final submitted version. Dr. Keegan contributed to the conception and design of the study, and acquisition as well as analysis and interpretation of data; participated in revising the article; and approved the final submitted version. Dr. Peters contributed to the conception and design of the study, and interpretation of data; participated in revising the article; and approved the final submitted version. Dr. Hubmayr contributed to the conception and design of the study, and interpretation of data; participated in revising the article; and approved the final submitted version.

Financial/nonfinancial disclosures: The authors have reported to the ACCP that no significant conflicts of interest exist with any companies/organizations whose products or services may be discussed in this article.

Role of sponsors: The contents of study are solely the responsibility of the authors and do not necessarily represent the official view of the National Center for Research Resources or the National Institutes of Health.

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