Timing of Admission to the Surgical Intensive Care Unit is Associated with in-Hospital Mortality

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Research

Keywords: Surgical intensive care unit; in-hospital mortality; intensivists; teaching hospital

Posted Date: February 3rd, 2021

DOI: <https://doi.org/10.21203/rs.3.rs-154631/v1>

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Version of Record: A version of this preprint was published at Journal of Acute Care Surgery on March 31st, 2022. See the published version at <https://doi.org/10.17479/jacs.2022.12.1.11>.

Abstract

Background: Knowledge about the relationship between timing of admission to the intensive care unit (ICU) and mortality among surgical patients admitted for acute care is limited.

Objective: We aimed to investigate whether admission to the surgical intensive care unit (SICU) during after-hours (all the times when intensivists were not staffed in the ICU) was associated with in-hospital mortality.

Methods: This retrospective cohort study was conducted at a tertiary academic hospital, in which we analyzed data of 571 patients admitted to the SICU whose complete medical records were available. The work-hours were defined as 07:00-19:00 from Monday to Friday during which intensivists were staffed in the ICU. The after-hours were defined as all other times during which intensivists were not staffed in the SICU. The primary outcome measurement was in-hospital mortality according to the time of SICU admission.

Results: In all, 333 and 238 patients were admitted to the SICU during work-hours and after-hours, respectively. Unplanned admissions (33.3% vs. 47.1%, $p<0.001$), Acute Physiology and Chronic Health Evaluation II score ≥ 25 (11.1% vs. 23.9%, $p<0.001$), ventilator support (17.4% vs. 34.0%, $p<0.001$), and use of inotropics (33.3% vs. 50.0%, $p<0.001$) were significantly higher in the after-hours group than in the work-hours group. In the multivariate analyses of the association between the time of SICU admission and in-hospital mortality, the timing of SICU admission was an independent factor for in-hospital mortality (OR=2.526; 95% CI=1.010-6.320, $p=0.048$).

Conclusions: In this study, we found that admission to the SICU during after-hours was associated with increased in-hospital mortality.

Introduction

Adequate treatment in the first few hours after the initial insult is an important factor influencing treatment outcomes in critically ill patients. [1, 2] Patients can develop a critical condition at any time; hence, critical care needs to be available at all times. Previous studies reported that higher staffing of intensivists in the intensive care unit (ICU) leads to a significant reduction in ICU and in-hospital mortality, and length of stay. [3–8] These improved outcomes were observed not only in the medical ICU, but also in the surgical intensive care unit (SICU). [9] However, due to the limited resources and high cost, it might not be always possible to staff the ICUs with intensivists at night and on weekends.

Most previous studies focused on patient outcomes related to intensivist staffing during after-hours in the medical ICUs. [10–14] The outcomes of admission during after-hours in the SICU hours remains unclear. In this study, we aimed to evaluate whether SICU admission during after-hours (all the times when intensivists were not staffed in the ICU) was associated with higher in-hospital mortality compared with admission during work-hours.

Methods And Materials

Study setting and patient enrollment

This retrospective study was conducted between March 2018 and February 2019 in Severance Hospital, Yonsei University Health System. Severance Hospital Yonsei University Health System is a high-volume, teaching, and referral hospital in Seoul, Korea. It has a 143-bedded ICU spread across 11 areas. This study was performed on surgical patients in one SICU and one mixed ICU in 11 areas. Severance Hospital follows a high-intensity staffing and a semi-closed ICU model. One intensivist with 3 years' experience and one second-year clinical fellow preparing for intensivist certification are staffed at the SICU from 7 am until 7 pm from Monday to Friday. A senior resident is in charge during after-hours. Real-time consultation during after-hours, by the work-hours intensivist is available according to the patient status.

Patients who were admitted to the SICU for any reasons were eligible for this study. Adult patients with trauma or post-transplant, and pediatric patients under 18 years of age were excluded. Of the 586 patients admitted to the SICU during the study period, 571 patients with complete medical records were finally enrolled.

Data collection

All demographic data including age, sex, Acute Physiologic and Chronic Health Evaluation (APACHE) II score, admission type, cause of ICU admission, number of ICU days, ventilator support required, and use of inotropic drugs were reviewed and analyzed. The primary outcome measurement was in-hospital mortality according to the time of SICU admission, while the secondary outcomes were ICU readmission within 48 hours, duration of ventilator support in days, length of ICU stay, length of hospital stay, and in-hospital mortality.

Definitions

The work-hours were defined to be from 7 am until 7 pm from Monday to Friday, during which intensivists were staffed in the SICU. The after-hours were defined as all other times during which intensivists were not staffed in the SICU. Planned admission was defined as SICU admission for postoperative monitoring or care after elective surgery, while all other admissions were defined as unplanned admissions.

Statistical analysis

Between-group differences were evaluated using the chi-square test or Fisher's exact test. Continuous variables were compared using the Student's t-test. The Cox proportional hazard model was used for multivariate analysis. All statistical tests were two-sided, and a p-value < 0.05 was considered statistically significant. All statistical tests were performed using SPSS version 25.0 (IBM, SPSS Inc., Chicago, IL).

Ethics statement

The study was approved by the Institutional Review Board of Severance Hospital, Yonsei, University Health System (approval number 4-2019-0412). The requirement for informed consent was not necessary

because of the retrospective nature of the study.

Results

In all, 333 (58.3%) and 238 (41.7%) patients were admitted to the SICU during work-hours and after-hours, respectively. The patients in the work-hours group were older than those in the after-hours group (mean age: 68.55 ± 12.52 vs. 64.06 ± 13.84 , $p < 0.001$). The number of patients with an APACHE II score of ≥ 25 was two times higher in the after-hours group than in the work-hours group (23.9% vs. 11.1%, $p < 0.001$). Unplanned admissions were also one-and-a half times higher during after-hours than during work-hours (47.1% vs. 33.3%, $p < 0.001$). Compared to the work-hours group, the proportion of patients who required ventilator support was two times higher in the after-hours group (17.4% vs. 34.0%, $p < 0.001$). Further, the proportion of patients who were administered inotropics was also almost two times higher in the after-hours group (50.0% vs. 33.3%, $p < 0.001$; Table 1).

Table 1

Clinicodemographic characteristics of the 571 SICU patients according to the timing of SICU admission

Patient characteristics	Work-hours (N = 333)	After-hours (N = 238)	p-value
Age, years	68.55 ± 12.52	64.06 ± 13.84	< 0.001
Sex			0.643
Male	212 (63.7%)	147 (61.8%)	
Female	121 (36.3%)	91 (38.2%)	
APACHE II score			< 0.001
<25	296 (88.9%)	181 (76.1%)	
≥25	37 (11.1%)	57 (23.9%)	
Admission type			< 0.001
Planned: Elective post-surgery	222 (66.7%)	126 (52.9%)	
Unplanned	111 (33.3%)	112 (47.1%)	
Emergency post-surgery	64 (19.2%)	71 (29.8%)	
Sepsis	23 (6.9%)	18 (7.6%)	
Cardiology	2 (0.6%)	6 (2.5%)	
Pulmonary	13 (3.9%)	7 (2.9%)	
Bleeding	4 (1.2%)	8 (3.4%)	
Neurology	3 (0.9%)	0 (0.0%)	
Others	2 (0.6%)	2 (0.8%)	
Number of ICU admissions so far			0.249
1st	318 (95.5%)	222 (93.3%)	
≥ 2nd	15 (4.5%)	16 (6.7%)	
Ventilator support required			< 0.001
No	275 (82.6%)	157 (66.0%)	
Yes	58 (17.4%)	81 (34.0%)	
Weaning			0.642

SICU = Surgical Intensive Care Unit, ICU = Intensive Care Unit, APACHE II score = Acute Physiologic and Chronic Health Evaluation II score

Patient characteristics	Work-hours (N = 333)	After-hours (N = 238)	p-value
Success	51 (87.9%)	69 (85.2%)	
Failure	7 (12.1%)	12 (14.8%)	
Central catheterization			0.207
No	29 (8.7%)	14 (5.9%)	
Yes	304 (91.3%)	224 (94.1%)	
Inotrope			< 0.001
Not required	222 (66.7%)	119 (50.0%)	
Required	111 (33.3%)	119 (50.0%)	
SICU = Surgical Intensive Care Unit, ICU = Intensive Care Unit, APACHE II score = Acute Physiologic and Chronic Health Evaluation II score			

The rate of ICU readmission within 48 hours was not significantly different between the work-hours group and the after-hours group (0.3% vs. 1.3%, $p = 0.313$). The median length of hospital stay was 15 and 20 days in the work-hours group and the after-hours group, respectively ($p < 0.001$). Compared to the work-hours group, the in-hospital mortality rate was approximately three times higher in the after-hours group (2.7% vs. 7.6%, $p = 0.007$; Table 2). Multivariate analyses showed that the time of SICU admission was an independent risk factor for in-hospital mortality (OR = 2.526; 95% CI = 1.010–6.320, $p = 0.048$). Unplanned admission (OR = 21.607; 95% CI = 2.789–167.407, $p = 0.003$) and ventilator support (OR = 52.269; 95% CI = 6.920–394.808, $p < 0.001$) were also independent predictors for in-hospital mortality with clinical significance (Table 3).

Table 2
Comparison of outcomes between the work-hours and after-hours groups

Outcomes	Work-hours group (N = 333)	After-hours group (N = 238)	p-value
ICU readmission within 48 hours			0.313
No	332 (99.7%)	235 (98.7%)	
Yes	1 (0.3%)	3 (1.3%)	
Median duration of ventilator support, days	2 (0–19)	2 (0–45)	0.721
Median length of ICU stay, days	1 (0–53)	2 (0–46)	0.977
Median length of hospitalization, days	15 (2-151)	20 (2-127)	< 0.001
In-hospital mortality rate	9 (2.7%)	18 (7.6%)	0.007
30-day mortality rate	7 (2.1%)	11 (4.6%)	0.089
SICU = Surgical Intensive Care Unit, ICU = Intensive Care Unit			

Table 3
Univariate and multivariate logistic regression models of factors associated with in-hospital mortality (N = 571)

Variables	Univariate	Multivariate	
	p-value	p-value	OR (95% CI)
Timing of admission			
Work-hours			
After-hours	0.007	0.048	2.526 (1.010–6.320)
Admission type			
Planned			
Unplanned	< 0.001	0.003	21.607 (2.789-167.407)
Age, years			
<65			
≥65	0.115	0.241	1.824 (0.668–4.982)
APACHE II score			
<25			
≥25	< 0.001	0.888	1.078 (0.378–3.075)
Ventilator support			
No			
Yes	< 0.001	< 0.001	52.269 (6.920-394.808)
APACHE II score = Acute Physiologic and Chronic Health Evaluation II score			

The planned admission subgroup and the unplanned admission subgroup involved 348 and 223 patients, respectively. In the planned admission subgroup, only one patient died (in-hospital mortality = 0.28%). Moreover, in the planned admission subgroup analysis, median length of hospital stay was higher in the after-hours group compared to that in the work-hours group (14 days vs. 18 days, $p < 0.001$). However, admission to the SICU during after-hours did not increase the in-hospital mortality (0.0% vs. 0.8%, $p = 0.362$; Supplementary table 1). In contrast, 26 patients in the unplanned admission subgroup died (in-hospital mortality = 10.31%). There was no significant difference between the work-hours group and after-hours group in terms of median length of hospitalization (18 days vs. 20 days, $p = 0.977$) and in-hospital mortality (8.1% vs. 15.2%, $p = 0.100$) in the unplanned admission subgroup analysis (Table 4).

Table 4

Clinicodemographic characteristics and outcomes according to the time of admission in the 223 patients who had unplanned SICU admission

Characteristics and outcome parameters	Work-hours (N = 111)	After-hours (N = 112)	p-value
Age, years	68.54 ± 12.88	65.93 ± 14.35	0.156
APACHE II score			0.128
<25	80 (72.1%)	70 (62.5%)	
≥25	31 (27.9%)	42 (37.5%)	
Ventilator support			0.742
No	62 (55.9%)	65 (58.0%)	
Yes	49 (44.1%)	47 (42.0%)	
Inotrope			0.515
Not required	37 (33.3%)	42 (37.5%)	
Required	74 (66.7%)	70 (62.5%)	
ICU readmission within 48 hours			-
No	111 (100.0%)	112 (100.0%)	
Yes	0 (0.0%)	0 (0.0%)	
Median ventilator support, days	3 (0–19)	3 (0–45)	0.522
Median length of ICU stay, days	3 (1–53)	3 (1–46)	0.844
Median length of hospitalization, days	18 (3–121)	20 (1–127)	0.977
In-hospital mortality rate	9 (8.1%)	17 (15.2%)	0.100
30 days of mortality rate	7 (6.3%)	11 (9.8%)	0.335
SICU = Surgical Intensive Care Unit, ICU = Intensive Care Unit, APACHE II score = Acute Physiologic and Chronic Health Evaluation II score			

Table 5
Univariate and multivariate logistic regression models of predictors of in-hospital mortality in the unplanned admission subgroup (N = 223)

Variables	Univariate	Multivariate	
	p-value	p-value	OR (95% CI)
Timing of admission			
Work-hours			
After-hours	0.100	0.058	2.449 (0.970–6.180)
Age, years			
<65			
≥65	0.289	0.336	1.650 (0.595–4.573)
APACHE II score			
<25			
≥25	< 0.001	0.921	0.947 (0.325–2.765)
Ventilator support			
No			
Yes	< 0.001	< 0.001	47.429 (6.253–359.730)
APACHE II score = Acute Physiologic and Chronic Health Evaluation II score			

Discussion

Previous research showed that intensivist staffing in the ICU leads to a significant reduction in ICU and in-hospital mortality, and length of stay. [3–9] However, the Society of Critical Care Medicine guidelines do not recommend 24/7 intensivist staffing in the ICU in high-intensity ICU models [5] based on only one randomized cohort study performed in the medical ICU. [15] To date, there is lack of evidence about whether admission in the SICU during after-hours is safe.

In this study, we investigated whether SICU admission during after-hours is associated with in-hospital mortality compared with admission during work-hours among patients who underwent surgical treatment. We found that admission to the SICU during after-hours increased the in-hospital mortality (OR = 2.526; 95% CI = 1.010–6.320, $p = 0.048$; Table 3). Moreover, unplanned admissions, APACHE II score ≥ 25 , need for ventilator support, and administration of inotropic drugs were also markedly higher in the after-hours group than in the work-hours group. These findings are important for the allocation and distribution of ICU resources, including intensivists.

Two systematic reviews reported that while patients admitted to an ICU over the weekend are at a higher risk of death, admission to the ICU during night hours did not appear to be associated with increased mortality. [16, 17] The authors inferred that lower level of staffing and intensity of care provided by many hospitals over the weekend might account for this finding. [5, 16, 17] In our study, “after-hours” was defined as the absence of the intensivists, and the results showed increased mortality in patients admitted to the SICU during after-hours. Although there was no change in the level of nurse staffing and intensity of care, and real-time consultation was provided by work-hour intensivists, absence of the intensivist might affect resolute decisions required during critical illness.

One recent study found that the out-of-office hours’ ICU admission after elective surgery was associated with significantly higher rates of postoperative complications, increased hospital length-of-stay, and increased inter-hospital transfers. [18] In our study, the subgroup analysis of patients admitted for planned surgery showed a higher median length of hospitalization in the after-hours group than in the work-hours group. This result might suggest that the cases with higher risk are referred to the SICU outside regular work-hours. Therefore, surgeons and anesthesiologists should plan surgeries of patients with higher risk towards the beginning of the surgical schedule for the day.

Despite the retrospective design and short period of the study, these findings might reflect the current status of most ICUs in Korea, considering that 82.3% of all ICUs are either in university teaching hospitals or in university-affiliated hospitals. [19] One of the main strengths of this study is that we specifically targeted surgical patients in conducting the research. Recently, O et al [20] reported a retrospective observational study of 10,708 postoperative patients showing an increased risk of 30-day mortality in the group without intensivist coverage. Compared to the previous studies performed in mixed or medical ICUs, [12, 14, 21–28] we only focused on postoperative SICU admissions. In our study, we included patients with unplanned admission including those who underwent emergency operations, those who developed postoperative sepsis, bleeding or other medical complications and we also included patients who had an elective postoperative status. The enrolled patients in this study represented the general population of patients who required intensive care postoperatively, and the results were consistent with those of previous studies. [18, 20, 29] Additionally, we performed subgroup analyses according to the causes of SICU admission to adjust for negative effects of unplanned admission on mortality.

Conclusion

Admission to the SICU during after-hours was associated with increased in-hospital mortality. Our findings have the potential to provide a guide to the hospitals for better patient safety and effective allocation of ICU resources.

Abbreviations

ICU: Intensive care unit; SICU: Surgical intensive care unit; APACHE: Acute Physiologic and Chronic Health Evaluation

Declarations

Ethics approval and consent to participate

The study was approved by the Institutional Review Board of Severance Hospital, Yonsei, University Health System (approval number 4-2019-0412).

Consent for publication

Not applicable

Availability of data and material

The datasets generated and/or analysed during the current study are not publicly available as they contain commercially sensitive information but are available from the corresponding author on reasonable request.

Competing of interests

The authors declare that they have no competing interests.

Funding

None

Authors' contributions

M.K.K., and I.K. participated in the literature search. All authors participated in the study design. M.K.K. participated in the data collection. M.K.K., and I.K. participated in the data analysis. All authors participated in the data interpretation. M.K.K., and I.K. participated in the writing. All authors participated in the critical revisions.

Acknowledgements

Not applicable

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