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The organizational structure of an intensive care unit influences treatment of hypotension among critically ill patients: A retrospective cohort study☆,☆☆

M. Dustin Boone, MD [a,b,*], Jennifer Massa, DSc [a,b], Ariel Mueller, MA [a,b], Sayuri P. Jinadasa, MD [a,b], Joon Lee, PhD [c,d], Rishi Kothari, MD [e], Daniel J. Scott, PhD [c], Julie Callahan, BSN [a], Leo Anthony Celi, MD, MPH [c], Michele R. Hacker, ScD, MSPH [b,f,**]

[a] Department of Anesthesia, Beth Israel Deaconess Medical Center, Boston, MA
[b] Harvard Medical School, Boston, MA
[c] Division of Health Sciences and Technology, Harvard-Massachusetts Institute of Technology, Cambridge, MA
[d] School of Public Health and Health Systems, University of Waterloo, Waterloo, ON, Canada
[e] Mount Sinai School of Medicine, New York City, NY
[f] Department of Obstetrics and Gynecology, Beth Israel Deaconess Medical Center, Boston, MA

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ABSTRACT

Purpose: Prior studies report that weekend admission to an intensive care unit is associated with increased mortality, potentially attributed to the organizational structure of the unit. This study aims to determine whether treatment of hypotension, a risk factor for mortality, differs according to level of staffing.

Methods: Using the Multiparameter Intelligent Monitoring in Intensive Care database, we conducted a retrospective study of patients admitted to an intensive care unit at Beth Israel Deaconess Medical Center who experienced one or more episodes of hypotension. Episodes were categorized according to the staffing level, defined as high during weekday daytime (7 AM–7 PM) and low during weekends or nighttime (7 PM–7 AM).

Results: Patients with a hypotensive event on a weekend were less likely to be treated compared with those that occurred during the weekday daytime ($P = .02$). No association between weekday daytime vs weekday nighttime staffing levels and treatment of hypotension was found (risk ratio, 1.02; 95% confidence interval, 0.98-1.07).

Conclusion: Patients with a hypotensive event on a weekend were less likely to be treated than patients with an event during high-staffing periods. No association between weekday nighttime staffing and hypotension treatment was observed. We conclude that treatment of a hypotensive episode relies on more than solely staffing levels.

1. Introduction

In the last decade, there has been emerging interest in the efficient allocation of health care resources to critically ill patients. One area of research has focused on the organizational structure of intensive care units (ICUs) and whether having more or less staff on duty affects patient outcomes. A recent meta-analysis demonstrated an increased risk of death for patients admitted to an ICU over the weekend [1]. They attributed this finding to the organizational structure and staffing differences on the weekend as compared with the weekday. Another study that examined intensivist coverage reported a higher mortality rate for those patients admitted to an ICU with low-intensity staffing, defined as either no intensivist coverage or elective intensivist consultation [2]. However, other studies have recently questioned the benefit of increased off-hour intensivist coverage [3]. Wallace et al [4] examined the organizational structure of 49 ICUs and found a mortality benefit associated with nighttime intensivist coverage for ICUs with low-intensity daytime coverage but not for ICUs with high-intensity daytime staffing. This finding was corroborated by a single-center, prospective trial in the medical ICU of an academic medical center that demonstrated no mortality benefit from overnight intensivist coverage [5]. An emerging body of literature suggests that the intensity of ICU staffing may reduce

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* Correspondence to: M. D. Boone, Department of Anesthesia, Beth Israel Deaconess Medical Center, 1 Deaconess Rd, Boston, MA 02215.
** Correspondence to: M. R. Hacker, Department of Obstetrics and Gynecology, Beth Israel Deaconess Medical Center, Boston, MA 02215.
E-mail address: mhacker@bidmc.harvard.edu (M.R. Hacker).

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the risk of mortality, although the physiological evidence for this association remains unclear. In addition, the association between hypotension and mortality, presumed to be secondary to organ dysfunction, is well established in the trauma literature [6,7]. We are unaware of published literature evaluating whether one possible cause of mortality, hypotension, is associated with staffing levels.

We aimed to further explore the association between staffing and patient care by investigating whether the management of sustained hypotension is associated with the level of ICU staffing. If a physiologic intervention were associated with staffing levels, it could have far-reaching implications for clinical management. We hypothesized that hypotension occurring during low-staffing periods would be associated with a reduced likelihood of hypotension treatment.

2. Methods

2.1. Patient cohort

This was a retrospective cohort study of patients admitted to ICUs at Beth Israel Deaconess Medical Center (BIDMC) in Boston, Mass, from 2001 through 2008. Patient data were extracted from the Multiparameter Intelligent Monitoring in Intensive Care II database [8] (version 2.6), which is a publicly available, deidentified ICU database developed jointly by the Massachusetts Institute of Technology, BIDMC, and Philips Healthcare. The institutional review board at BIDMC approved the study protocol with a waiver of informed consent.

Eligibility criteria included age greater than 15 years; admission to the medical ICU, surgical ICU, coronary care unit, or cardiac surgery recovery unit; at least one hypotensive episode (HE) during the ICU admission; and complete data for potential confounders. We excluded patients with a do-not-resuscitate or do-not-intubate order in effect at any time during their ICU admission. An HE was identified using mean arterial pressure (MAP) measurements recorded using invasive arterial catheters or noninvasive sphygmomanometers. If both measurement techniques were available for the same time point, invasive measurements were analyzed. In general, both types of MAP measurements were recorded every 10 to 15 minutes. The beginning of an HE was defined as the time of the first of 2 consecutive MAP measurements less than 60 mm Hg, preceded by 2 consecutive MAP values greater than or equal to 60 mm Hg. The end of the HE was defined as the time of the first of 2 consecutive MAP measurements greater than or equal to 60 mm Hg, after the beginning of the HE.

2.2. Study variables and outcomes

The primary exposure was staffing level at the onset of the HE. Weekday daytime (7AM to 7PM) was considered a high-staffing period, whereas weekday nighttime (7PM to 7 AM), weekend daytime, and weekend nighttime were considered as 3 distinct periods of low-staffing.

Throughout the study period, core staffing at BIDMC typically consisted of 5 nurses for 8 patients, allowing for 2 of those patients to have a 1:1 patient to nurse ratio, whereas less acute patients had a 2:1 ratio. This core nursing staff structure was the same for all 4 exposure periods.

During weekday daytime, the high-staffing period, each ICU was staffed with a resource nurse and unit-based educator, as well as 1 attending, 3 residents, and often a fellow. Weekend daytime staffing consisted of the primary attending and fellow for each unit present for morning rounds and then available by telephone, and 1 in-house resident per unit. During both weekday nighttime and weekend nighttime, the primary attending was available by telephone, there was 1 in-house resident for each unit, and there was 1 overnight in-house attending to cover all units. Weekends (both daytime and nighttime) are staffed with the same core nursing staff that staffs the units during the week. The primary outcome of interest was any HE treatment; secondary outcomes included treatment with fluid resuscitation, or vasoactive therapy only. *Fluid resuscitation* was defined as one or more infusions of either a bolus of isotonic crystalloid of at least 250 mL or any nonzero volume of colloids. *Vasoactive therapy* was defined as the initiation of or increase in dosage of any vasoactive agent during the HE. The following vasoactive agents were considered: dobutamine, dopamine, epinephrine, norepinephrine, phenylephrine, and vasopressin.

The following variables were considered potential confounders and assessed for inclusion in the models: age, sex, Elixhauser Comorbidity Index for in-hospital death [9,10], Simplified Acute Physiologic Score (SAPS) I (a predictor of mortality for critically ill patients), MAP in the 3-hour period immediately prior to HE onset, total volume of urine output in the 3-hour period immediately prior to HE onset, last serum creatinine level prior to and within 24 hours of the HE onset, the total volume of fluids (normal saline or lactated ringer) given to the patient between ICU admission and HE onset, and service type on admission.

2.3. Statistical analysis

We used modified Poisson regression with robust error variance, which accounts for the repeated HE episodes in the same individual, to estimate the risk ratio (RR) and 95% confidence interval (CI) for the association between staffing intensity and each of the primary outcomes: fluid resuscitation, vasoactive therapy, and any HE treatment [11]. We then used multivariable models to assess the influence of all potential confounders listed above and retained those variables that had an appreciable effect on the association. Consequently, the final models were adjusted for age, SAPS I, number of blood pressure measurements per hour, minimum blood pressure during the HE, hours since ICU admission, and mean blood pressure 3 hours before the HE [12]. For all regression models, P values less than .05 were considered statistically significant. All statistical analyses were performed using SAS 9.3 (SAS Institute, Cary, NC).

3. Results

Fig. 1 depicts how we applied our exclusion criteria to the Multiparameter Intelligent Monitoring in Intensive Care II patient population of 32 426 to arrive at 6446 eligible patients. The study population had a slightly larger proportion of men (54.3%), a mean age of 66.7 ± 15.9 years, and a mean Elixhauser Comorbidity Index of 2.6 ± 5.5 (Table 1). There were 21 003 HEs, with a mean of 2.6 ± 3.4 HEs per patient during the ICU stay. The mean MAP during HEs was 58.8 ± 3.9 mm Hg, whereas the mean minimum MAP during HEs was 51.9 ± 5.6 mm Hg.

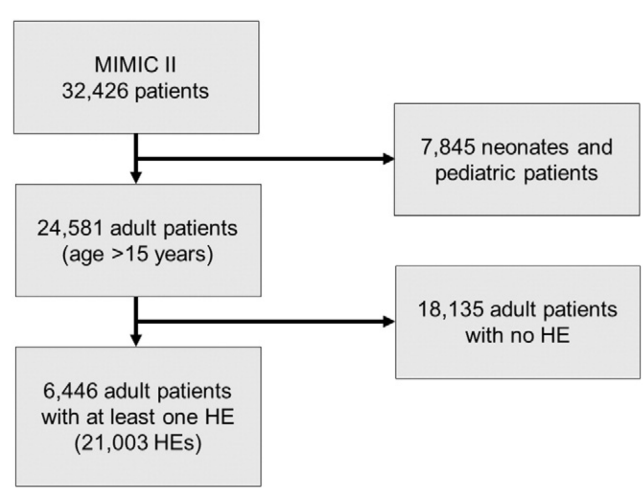

Fig. 1. Exclusion criteria applied to the Multiparameter Intelligent Monitoring in Intensive Care patient database.