Intensivists Improve Outcomes and Compliance with Process Measures in Critically Ill Patients

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BACKGROUND: Specialty-trained intensivist involvement in the care of critically ill patients has been associated with improved outcomes; however, the factors contributing to this observation are unknown. We hypothesized that intensivist-led ICU care would result in decreased mortality, length of stay, and rate of deep venous thrombosis/pulmonary embolism along with improved compliance with ICU process measures.

STUDY DESIGN: We performed a retrospective review of 847 patients using the October 2008 transition at a regional medical center from an open ICU to a model in which board-certified intensivists assume primary responsibility or co-management of all critically ill patients. Included in the analysis were patients admitted to the ICU during the 3 months immediately before the transition (June to September 2008) and a 3-month period 1 year later (June to September 2009). End points included mortality, length of stay, and deep venous thrombosis/pulmonary embolism rates, as well as several ICU process measures.

RESULTS: Patients in the post-intensivist cohort had a shorter hospital length of stay (7.4 days vs 8.7 days; $p = 0.009$) and a trend toward decreased mortality (9.3% vs 13.3%; $p = 0.086$). Patients also received timely initiation of deep venous thrombosis prophylaxis more frequently and tended toward more frequent timely initiation of nutritional support. Patients in the post-intensivist cohort admitted to the ICU with sepsis demonstrated a significant decrease in mortality (11.4% vs 35.0%, $p = 0.010$), both overall and in patients with APACHE II scores >20.

CONCLUSIONS: Intensivist-led ICU care is associated with improved outcomes in patients with sepsis and possibly in all ICU patients. Compliance with selected evidence-based practices improved. Additional study is needed to understand the mechanisms by which the intensivist model improves outcomes. (J Am Coll Surg 2013;216:363−372. © 2013 by the American College of Surgeons)

Almost 3 decades ago, Li and colleagues published a study documenting decreased mortality in a community hospital ICU managed by 24-hour on-site physician staffing.[1] Several years later, Pronovost and colleagues[2] observed that daily rounds by an ICU physician were associated with decreased in-hospital mortality and decreased complications in patients undergoing abdominal aortic surgery. The association between the presence of intensivists (defined in multiple ways) and improved outcomes has been confirmed in several subsequent studies.[3-8] However, the exact mechanisms behind this benefit remain unclear. Potential explanations include the training and expertise of board-certified intensivists and increased access to these specialty-trained physicians. Others have suggested that multidisciplinary care teams are responsible for at least a portion of the advantage afforded by intensivists.[9]

Another potential cause is improved compliance with ICU protocols or general improvements in ICU process in an intensivist-led critical care delivery system. To date, there is a paucity of data about the impact of intensivists on compliance with ICU process measures. We hypothesized that the involvement of board-certified intensivists would be associated with improved outcomes, but would also be associated with improved compliance with ICU process measures.

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Abbreviations and Acronyms

DVT = deep vein thrombosis
GI = gastrointestinal
LOS = length of stay
PE = pulmonary embolism

METHODS

In October 2008, the physician-staffing model in one of our affiliated hospital's single 24-bed mixed medical/surgical/cardiovascular surgery and neurosurgery ICU changed. The hospital is a nonteaching hospital staffed by a hospital-employed hospitalist service and numerous independent specialty practices with privileges and patient care responsibilities at other hospitals in the area. Previously, medical staff could request critical care consults for their patients in the ICU, but these consults were not required. The critical care consultation and ongoing patient management was provided primarily by a nephrology practice with assistance from other specialties, such as pulmonary (mostly for ventilator management), infectious disease, cardiology, etc. This was changed in 2008 to an intensivist model in which the hospital contracted with intensivists (pulmonary and critical care fellowship-trained or critical care fellowship-trained) from faculty at the University of Minnesota Medical School to provide three shifts of scheduled on-site intensivist presence (with no other clinical responsibilities) from 7 AM to 11 PM (7 AM to 12 PM, 9 AM to 6 PM, 6 PM to 11 PM) on the weekdays and 7 AM to 5 PM on the weekends, with immediate after-hours availability (late-shift person stayed later than 11 PM or returned from home about 50% of the time) for admissions or unstable patients. Although the intensivists were available at night, in-house presence at night was not required.

By the definition used by Pronovost and colleagues,[8] the new intensivist staffing model can be described as high intensity. The intensivists were the primary physicians for critically ill patients (eg, intubated, requiring hemodynamic support, bleeding, etc) unless another specialist (usually a surgical specialty such as cardiovascular or vascular surgery or the single neurointensivist) was the admitting physician, in which case the intensivists co-managed, especially during off hours. Hospitalists were in house overnight and could admit and manage their patients in the ICU as long as they did not meet written severity guidelines. Formal "intensivist" consults were not required for the intensivists to evaluate and stabilize any deteriorating patient in the ICU or if the patients met the written severity criteria. Only rarely did both an intensivist and a hospitalist co-manage patients. In total, the intensivists primarily managed approximately 70% of all patients admitted to the ICU with the remainder of patients representing subacute patients who did not meet written severity guidelines and did not require intensivist expertise.

We performed a retrospective study, reviewing the electronic medical records for all ICU admissions from July 1, 2008 through September 30, 2008 (pre-intensivist group) and from July 1, 2009 through September 30, 2009 (post-intensivist group). We chose this time period after the change to allow for stabilization of the new care model and to minimize seasonal variability. We obtained data from the hospital administrative database, which included age, race/ethnicity, date of hospital admission and discharge, hospital length stay (LOS), ICU LOS, hospital discharge status (ie, expired, discharge to home, discharge to inpatient rehabilitation, etc), hospital admission diagnosis, ventilator days, and development of pulmonary embolism (PE) or deep venous thrombosis (DVT) and use of central venous catheters. Through chart review, we collected data on timing of ICU admission and on several ICU process measures. These variables are listed in Table 1.

We collected additional information on 2 subgroups of our patient population. The first subgroup included patients requiring prolonged mechanical ventilation (defined as >48 hours) to minimize the influence of mechanical ventilation outcomes by postoperative patients (ie, cardiac surgery) who arrived in the ICU intubated but were routinely extubated once they awoke from anesthesia. Data on the use of positive pressure mask ventilatory support were not collected. The variables collected on these patients are also included in Table 1. The second subgroup of patients included those patients admitted with an infection as documented by the admitting physician. Although the original intent for this categorization was to assess the timing of antibiotics, patients were retained for additional analysis if the discharge diagnosis was sepsis or septic shock. For this group of patients, data were gathered for the purpose of calculating APACHE II scores, APACHE III scores, and Sequential Organ Failure Assessment scores. Data on the development of renal failure, the need for dialysis, and the need for intensive insulin therapy (ie, continuous insulin infusion) were recorded for this group of patients.

Statistical analysis

All data analyses were performed using SPSS version 19.0 (SPSS, Inc.). Continuous or scale variables were compared using Student's *t*-test and Mann-Whitney

Table 1. Variables Collected during Chart Review

Day of ICU admission	
ICU admission diagnosis*	
Receipt of antibiotics within 6 hours of ICU admission†	
Type of antibiotics received	
Any plateau pressure ≥30 cmH_2O‡	
Mechanical and/or chemical DVT prophylaxis by 5 pm on ICU day 2	
Type of DVT prophylaxis administered	
GI prophylaxis§ by 5 pm on ICU day 2	
Nutritional support within 48 hours of ICU admission‖	
Additional variables	
Patients requiring mechanical ventilation ≥48 hours	
Ventilator hours	
Reintubation event	
Tracheotomy event	
No. of ventilator measurements¶ in first 72 hours	
No. of plateau pressure measurements in first 72 hours	
Total and percentage of plateau pressure measurements ≥30 cm H_2O	

*Working diagnosis at time of ICU admission based on admitting physician's notes.
†For patients with suspected infection only.
‡For patients requiring mechanical ventilation only.
§Typically H_2 blocker or proton pump inhibitor, excluding patients receiving therapeutic continuous intravenous proton pump inhibitor.
‖Includes resumption of oral intake, includes medical and surgical patients.
¶Ventilator settings (ie, mode, respiratory rate, set tidal volume, PEEP, FiO_2, etc) and measurements including peak airway pressure, mean airway pressure, plateau pressure, and minute ventilation.
DVT, deep vein thrombosis; GI, gastrointestinal.

U nonparametric testing where appropriate. Categorical or nominal variables were compared using chi-square and Fisher's exact test where appropriate. Multivariate analysis was performed on the septic patient cohort using multinomial logistic regression. Given the small sample size of this particular cohort, the model was limited to variables showing significant linkage to mortality in univariate analysis so as to limit the degrees of freedom. A p value of <0.05 was considered statistically significant.

RESULTS

There were 375 patients in the pre-intensivist group and 388 patients in the post-intensivist group. Table 2 illustrates the patient characteristics of the 2 study groups. The 2 groups were similar with respect to age, sex, and ethnicity. There was not a significant difference in the rate of weekend ICU admissions between the 2 groups. The post-intensivist group included fewer postoperative patients and more patients with respiratory failure compared with the pre-intensivist group. In addition, the post-intensivist group included fewer patients that required mechanical ventilation compared with the pre-intensivist group. Central venous catheters were used more frequently in the post-intensivist group.

Table 2. Intensive Care Unit Patient Characteristics

	Pre-intensivist (n = 375)	Post-intensivist (n = 388)	p Value*
Age, y	64.7	64.6	0.944
Sex, male, %	55.5	54.6	0.818
Ethnicity, Caucasian, %	85.9	87.6	0.365
Weekend ICU admission, n (%)†	74 (19.7)	90 (23.2)	0.244
ICU admission diagnosis, n (%)‡			
Infection/sepsis	65 (17.3)	73 (18.8)	0.595
Postoperative	116 (30.9)	78 (20.1)	0.001
ACS/cardiac arrest	63 (16.8)	68 (17.5)	0.790
Altered mental status§	17 (4.5)	17 (4.4)	0.920
Respiratory failure	20 (5.3)	37 (9.5)	0.027
Cerebrovascular‖	35 (9.3)	54 (13.9)	0.049
Other	59 (15.7)	61 (15.7)	1.000
Required central line	99 (26.4)	141 (36.3)	0.003
Required mechanical ventilation	188 (50.1)	148 (38.1)	0.001

*Chi-square for categorical variables, Student's *t*-test for continuous (scale) variables.
†Weekend defined as Saturday and Sunday.
‡Refers to working diagnosis on admission to the ICU.
§Excludes patients with identified cerebrovascular etiology or lesion.
‖Stroke, traumatic, etc.
ACS, acute coronary syndrome.

Mortality

Overall in-hospital mortality was 11.3%. The post-intensivist group had a lower in-hospital mortality compared with the pre-intensivist group (9.3% compared with 13.3%), although this did not reach statistical significance (p = 0.086, Fisher's exact test). Weekend admission to the ICU had no statistically significant impact on mortality in either group, regardless of definition as Friday to Sunday or Saturday to Sunday (data not shown). When stratified by ICU admission diagnosis, in-hospital mortality was markedly lower for patients admitted with an infection in the post-intensivist group compared with the pre-intensivist group (6.8% compared with 24.6%; p = 0.004, Fisher's exact test). No significant differences in in-hospital mortality existed between the 2 groups with respect to the other categories of ICU admission diagnosis. These data are summarized in Figure 1. For those patients who survived, there was not a significant difference between the 2 groups in the proportion of patients who were discharged to home (56.5% for pre-intensivist group compared with 53.4% for the post-intensivist group; p = 0.440, Fisher's exact test) vs a skilled nursing facility, inpatient rehabilitation center, long-term acute care hospital, etc.

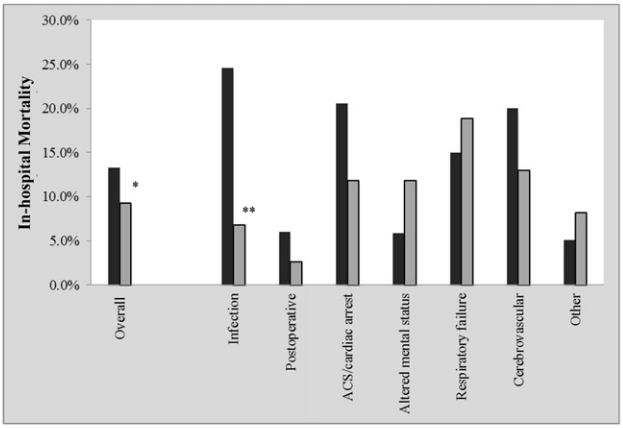

Figure 1. In-hospital mortality in ICU patients before and after intensivist involvement. ACS, acute coronary syndrome. *p = 0.086; **p = 0.004 (Fisher's exact test); the remainder all have p values > 0.2. Black bar, pre-intensivist; gray bar, post-intensivist.

Length of stay

Although ICU LOS was not significantly different between the 2 groups, hospital LOS was significantly lower for the post-intensivist group compared with the pre-intensivist group (mean 7.4 days compared with 8.7 days; p = 0.009, Mann-Whitney U test). There was no significant difference between the groups in the proportion of patients who had withdrawal of support as documented in the discharge/death summary. When stratified by ICU admission diagnosis, patients admitted with an acute coronary syndrome or cardiac arrest in the post-intensivist group had a shorter ICU and hospital LOS compared with those in the pre-intensivist group (mean/median ICU LOS 2.0/1.0 days compared with 3.9/2.0 days; p = 0.009, Mann-Whitney U test; mean/median hospital LOS 6.0/4.5 days compared with 9.3/8.0 days; p = 0.015, Mann-Whitney U test). Similarly, patients admitted with respiratory failure in the post-intensivist group had a shorter hospital LOS (mean/median hospital LOS 7.3/4.0 days vs 11.0/9.0 days, p = 0.048; Mann-Whitney U test) compared with those patients with respiratory failure in the pre-intensivist group. The ICU LOS for patients admitted with respiratory failure was not significantly different between the 2 groups. There was no significant difference in ICU or hospital LOS for patients admitted with infection or sepsis.

Process of care

Patients in the post-intensivist group were more likely to receive DVT prophylaxis, either mechanical or chemical by 5 PM on ICU day 2, than patients in the pre-intensivist group (p < 0.001, Fisher's exact test). This analysis excluded patients who were therapeutically anticoagulated, discharged from the ICU before the specified time point, or had a contraindication to DVT prophylaxis. These data are highlighted in Table 3. The vast majority of patients in whom chemical DVT prophylaxis was deemed contraindicated within our designated time frame were postoperative cardiac patients. Despite this difference, there was no statistically significant difference in the rate of DVT/PE (pre-intensivist 1.6% vs post-intensivist 3.4%; p = 0.163, Fisher's exact test). Additionally, more patients in the post-intensivist group received nutritional support (either resumption of oral intake or supplemental feeds, either enteral or parenteral) within 48 hours of ICU admission compared with the pre-intensivist group, although this difference did not reach statistical significance. Conversely, patients in the post-intensivist group were less likely to receive gastrointestinal (GI) ulcer prophylaxis by 5 PM on ICU day 2 than those in the pre-intensivist group, although this trend also did not reach statistical significance.

Table 3. Nutrition and Prophylaxis

	Pre-intensivist (n = 375)	Post-intensivist (n = 388)	p Value*
Nutrition, n (%)[†]	276 (81.9)	318 (86.6)	0.096
GI prophylaxis, n (%)[‡,§]	246 (73.9)	255 (67.8)	0.083
DVT prophylaxis, %[‡]			
Any	27.2	77.4	<0.001
Mechanical	15.9	62.2	<0.001
Chemical	27.5	61.6	<0.001
Excluded, n (%)[‖]			
Anticoagulated	72 (19.2)	96 (24.7)	0.067
Discharged before 5 PM ICU day 2	64 (17.1)	22 (5.7)	<0.001
Mechanical prophylaxis contraindicated	0 (0)	3 (0.8)	0.249
Chemical prophylaxis contraindicated	119 (31.7)	124 (32.0)	1.000

*Fisher's exact test (2-sided).
[†]Resumption of oral intake or initiation of nutritional support within 48 hours of ICU admission. Excludes patients who were discharged before 48 hours (n = 34, pre-intensivist, n = 12, post-intensivist) or had nutrition withheld per comfort care directive (n = 4, pre-intensivist, n = 9, post-intensivist).
[‡]Must be administered by 5 PM on ICU day 2.
[§]Excludes patients who were discharged before 5 PM on ICU day 2 (n = 35, pre-intensivist, n = 5, post-intensivist). Excludes patients receiving proton pump inhibitor gtt treatment for GI bleed (n = 7, pre-intensivist, n = 7, post-intensivist).
[‖]Excluded from DVT prophylaxis analysis.
DVT, deep vein thrombosis; GI, gastrointestinal.

Ventilator

There were more patients who required mechanical ventilation in the pre-intensivist group overall when compared with the post-intensivist group, with a corresponding increase in patients receiving mechanical ventilation ≥48 hours in the pre-intensivist group. There were no statistically significant differences between the 2 groups, in patients that required ventilatory support ≥48 hours, with respect to the number of ventilator measurements obtained in the first 72 hours, the number of plateau pressure measurements recorded in the first 72 hours or the total and fraction of plateau pressure measurements recorded that were ≥30 cmH_20. Likewise, there were no significant differences in mortality, time on the ventilator (ventilator days or ventilator hours), reintubation rates, tracheotomy rates or time to tracheotomy between the 2 groups (data not shown).

Sepsis

There were 65 patients in the pre-intensivist group and 73 patients in the post-intensivist group admitted to the ICU with an infection as the admission diagnosis. Of these patients, 40 patients in the pre-intensivist group and 44 patients in the post-intensivist group had a confirmed discharge diagnosis of sepsis, severe sepsis, or septic shock and received treatment for such. For the remainder of patients, the infection diagnosis was either refuted based on laboratory and clinical data (eg, COPD exacerbation instead of pneumonia) or was believed to be a secondary problem, with another diagnosis providing the major impetus for the ICU level of care (eg, incidental urinary tract infection in a patient admitted with stroke). The findings in this subgroup of patients are provided in Tables 4 and 5. The 2 groups were statistically similar with respect to age, sex, and ethnicity. More patients in the pre-intensivist group required mechanical ventilation compared with the post-intensivist group (55.0% vs 36.7%); however, this difference did not reach statistical significance (p = 0.124, chi-square). The 2 groups were similar in the percentage of patients who had acute renal failure develop and who required vasopressive agents or intensive insulin therapy. On average, the APACHE II score was higher for pre-intensivist group patients than for post-intensivist group patients (27.5 vs 22.8; p = 0.026, Mann-Whitney U test). Mean APACHE III scores were also higher for the pre-intensivist group. There was no statistical difference in mean initial Sequential Organ Failure Assessment score between groups.

There was no statistically significant difference in ICU mortality between the 2 groups, however; the in-hospital mortality was higher for the pre-intensivist group than for the post-intensivist group (35.0% vs 11.4%; p = 0.010, chi-square). There was no statistically significant difference in ICU or hospital LOS between the 2 groups. In an attempt to account for differences in baseline severity of illness, as evidenced by the higher mean APACHE II score in the pre-intensivist group, we stratified patients into groups with APACHE II scores ≤20 and scores >20. Even with this constraint, the in-hospital mortality difference remains significantly lower for the post-intensivist group (Fig. 2).

The results of the multivariate analysis for the sepsis subset of patients are shown in Figure 3. The analysis was limited to variables that showed a significant association with mortality during univariate analysis. This restriction was imposed to limit the degrees of freedom given the small size of the groups during this subgroup analysis. These variables were study group (pre/post-intensivist), APACHE II score, sex, and need for mechanical ventilatory support (univariate data for each variable not shown with exception of study group). Only the APACHE II score retained statistical significance in multivariate analysis. A 1-point increase in APACHE II score was associated with an odds ratio of death of 1.6 (95% CI, 1.2–2.1; p = 0.001). Although not reaching statistical significance, intensivist-led management (ie, post-intensivist group) was associated with an odds ratio

Table 4. Sepsis Subgroup Analysis: Demographic Data

	Pre-intensivist (n = 40)	Post-intensivist (n = 44)	p Value*
Age, y			0.103†
Mean (SD)	70.6 (16.2)	65.0 (15.3)	
Median (range)	71.5 (40–92)	65.5 (26–95)	
Sex, male, n (%)	24 (60.0)	21 (47.7)	0.260
Ethnicity, Caucasian, n (%)	34 (85.0)	38 (86.4)	0.858
Mechanical ventilation, n (%)	22 (55.0)	16 (36.7)	0.087
Vasopressors, n (%)	25 (62.5)	25 (56.8)	0.596
Insulin drip, n (%)	22 (55.0)	17 (38.6)	0.133
ARF/AKI, n (%)	22 (55.0)	18 (40.9)	0.197
APACHE II score			0.026†
Mean (SD)	27.5 (9.9)	22.8 (8.1)	
Median (range)	28 (7–57)	22.5 (10–42)	
APACHE III score			0.005†
Mean (SD)	99.3 (37.1)	78.3 (39.4)	
Median (range)	92.5 (37–217)	74.5 (34–267)	
Initial SOFA score			0.079†
Mean (SD)	7.5 (3.5)	6.2 (3.8)	
Median (range)	7.5 (1–16)	5.0 (1–17)	

*Chi-square test, unless otherwise specified.
†Mann-Whitney U test.
AKI, acute kidney injury; ARF, acute renal failure; SOFA, Sequential Organ Failure Assessment.

Table 5. Outcomes in Sepsis Cohort

	Pre-intensivist (n = 40)	Post-intensivist (n = 44)	p Value
In-hospital mortality, %	35.0	11.4	0.010*
ICU mortality, %	25.0	11.4	0.103*
Hospital LOS, d, mean (median)	13.7 (7.0)	12.5 (8.0)	0.638†
ICU LOS, d, mean (median)	7.9 (3.0)	6.7 (4.0)	0.573†
DVT/PE rate, n (%)	0 (0.0)	1 (2.3)	0.337*
Ventilator days, mean (median)‡	8.3 (4.5)	9.7 (6.0)	0.680†
Antibiotics within 1 h, n (%)	39 (97.5)	44 (100)	0.476*
Nutrition, n (%)§	18 (58.1)	35 (79.5)	0.070*
GI prophylaxis, n (%)‖	27 (77.1)	36 (81.8)	0.779*
DVT prophylaxis, n (%)			
Any DVT prophylaxis¶	11 (40.7)	32 (88.9)	<0.001
Mechanical DVT prophylaxis#	4 (15.4)	20 (55.6)	0.002**
Chemical DVT prophylaxis#	7 (36.8)	22 (75.9)	0.015**

*Chi-square test.
†Student's *t*-test.
‡Vented patients only (pre-intensivist, n = 22; post-intensivist, n = 16).
§Resumption of oral intake or initiation of nutritional support within 48 hours of ICU admission. Excludes patients discharged before 48 hours (n = 9, pre-intensivist, n = 0, post-intensivist).
‖Patients who had prophylaxis documented but were still discharged before 5 PM on ICU day 2 were counted as having received prophylaxis.
¶Excludes patients who were discharged before 5 PM on ICU day 2 (n = 6, pre-intensivist, n = 0, post-intensivist), patients who were therapeutically anticoagulated (n = 7, pre-intensivist, n = 8, post-intensivist).
#Excludes patients in whom this type of prophylaxis was contraindicated (Sequential compression devices, n = 1, pre-intensivist, n = 0 post-intensivist) (chemical n = 8, pre-intensivist, n = 7, post-intensivist).
**Fisher's exact test.
DVT, deep vein thrombosis; GI, gastrointestinal; LOS, length of stay; PE, pulmonary embolism.

of death of 0.25 (95% CI, 0.1–1.6; p = 0.138). Inversely, the odds ratio was 4.0 (95% CI, 0.6–25.7; p = 0.138) in favor of survival.

Similar to the entire cohort, septic patients in the post-intensivist group were more likely to receive either mechanical or chemical DVT prophylaxis by 5 PM on ICU day 2, than patients in the pre-intensivist group (Table 5). Also, patients in the post-intensivist group tended to receive nutritional support within 48 hours of ICU admission more frequently than patients in the pre-intensivist group, although this difference did not reach statistical significance. There was no significant difference in the rate of receiving GI prophylaxis between the 2 groups.

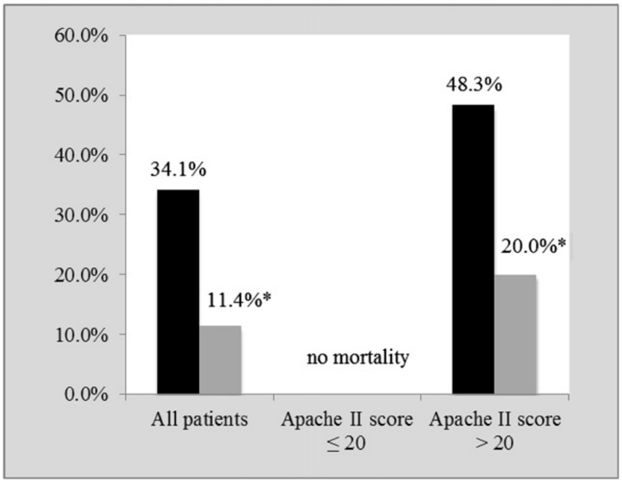

Figure 2. In-hospital mortality stratified by APACHE II score. *p < 0.05. Black bar, pre-intensivist; gray bar, post-intensivist.

DISCUSSION

Our results complement the existing literature on improved outcomes associated with primary involvement of board-certified intensivists in the management of critically ill patients. In our single-institution retrospective study, we discovered that a change from an open ICU, elective intensivist involvement model to a high-intensity model in which board-certified intensivists are involved in the management of all critically ill patients without competing clinical responsibilities is associated with improved outcomes. In particular, intensivist involvement is associated with a reduced hospital LOS and a trend toward decreased in-hospital mortality. In addition, we observed that intensivist involvement was associated with improved measures of ICU process, including a significantly higher rate of initiation of

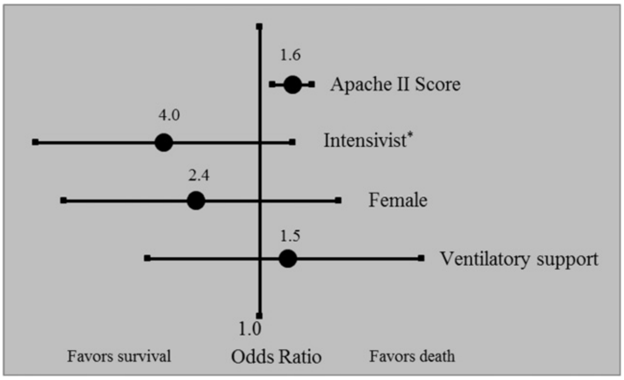

Figure 3. Sepsis subgroup analysis: multivariate analysis. *Represents the inverse of the odds ratio presented in the results section, obtained by performing analysis with the reversed survival reference point.

mechanical and chemical DVT prophylaxis and a trend toward more frequent initiation or resumption of nutritional support within 48 hours. Intensivist involvement was also associated with more frequent use of central lines. However, there was not a significant difference in the (very low) rate of clinically diagnosed DVT/PE to accompany the difference in rates of DVT prophylaxis, which would have linked a process measure with particular outcomes.

That the presence of intensivists does improve outcomes has been well established. As mentioned, Li and colleagues published one of the earliest studies documenting decreased mortality in a community hospital ICU managed by 24-hour on-site physician staffing.[1] Subsequently, Pronovost and colleagues[2] observed that daily rounds by an ICU physician were associated with decreased in-hospital mortality and decreased complications in patients undergoing abdominal aortic surgery. The association between the presence of intensivists (defined in multiple ways) and improved outcomes has been confirmed in several subsequent studies.[3-8] In a large systematic review and meta-analysis, Pronovost and colleagues[8] showed that high-intensity ICU physician staffing—defined as either a closed ICU or mandatory involvement of intensivists in the care of ICU patients—was associated with reduced hospital and ICU mortality and reduced hospital and ICU LOS, when compared with low-intensity staffing—defined as an open ICU or elective intensivist consultation. They observed a hospital mortality unadjusted relative risk ratio of 0.71 (95% CI, 0.62−0.82) and an ICU mortality relative risk ratio of 0.61 (95% CI, 0.50−0.75) in favor of high-intensity staffing. In addition, 10 of 13 studies that reported hospital LOS as an outcomes measure found it to be significantly reduced with high-intensity staffing.

However, a recent large study obtained disparate results. Levy and colleagues[10] conducted a retrospective review of a large, prospectively maintained database of ICU patients (Project IMPACT). At final analysis, >100,000 patients were included. The primary outcomes variables included hospital mortality and controlled for patient, ICU, and hospital characteristics. They found that patients managed by critical care physicians had greater severity of illness and received more procedures than patients who were not managed by critical care physicians. In addition they found that patients managed by critical care physicians had a higher hospital mortality rate than those not so managed. This mortality difference remained significant despite adjusting for severity of illness. Although the authors were unable to explain the findings, several potential explanations were put forth, including residual confounding variables not accounted for in the severity of illness model used (expanded Simplified Acute Physiology Score II) and unreported comorbid conditions or other additional diagnoses in the Project IMPACT database. The possibility that management by critical care physicians was associated with worse outcomes in their study rather than the results being an erroneous finding was also considered. Disregard of established protocols, the increased use of invasive procedures with their associated complications, and lack of involvement with familiar physicians were all proposed as potential causes for the unanticipated results. It is unclear, however, how these factors eluded detection in the multiple other studies showing that management by critical care physicians is beneficial.

Despite the findings of this study, the overwhelming majority of literature on this subject reports improved outcomes with the involvement of intensivists. The logical progression, as some have proposed,[11,12] is that ICUs shift to 24-hour intensivist staffing. This has been proposed in light of data that indicate that ICU patients are more likely to die at night[13] and that critically ill patients admitted to the hospital during off hours have a higher mortality.[14] Although the argument for 24-hour in-house intensivist coverage is compelling, there are few data available to support this practice. Gajic and colleagues[15] were able to demonstrate improved compliance with ICU care processes, decreased complications, and decreased hospital LOS with a change from on-demand (intensivist at home, but could be at bedside within 15 to 30 minutes) night-time intensivist staffing to in-house night-time intensivist staffing. They also showed improved staff satisfaction. However, a very recent study by Wallace and colleagues[16] demonstrated that night-time intensivist staffing was associated with decreased in-hospital mortality among ICU patients—if the daytime intensivist staffing model was low-intensity (defined as optional intensivist consultation for critically ill patients). For ICUs with high-intensity daytime intensivist staffing (defined as mandatory intensivist consultation or transfer of primary responsibility to the intensivist), night-time intensivist staffing was not associated with a reduction in mortality. These data are somewhat supported by another recent study,[17] which found that addition of mandatory night-time coverage to an already high-intensity staffed ICU in the daytime did not effect long-term survival in analysis of medical ICU patients.

In the current study, the model change described is that of a low-intensity intensivist staffing to a high-intensity intensivist staffing model. This description is consistent with the definitions of low-intensity and high-intensity mentioned previously.[8,16] In addition, these data would suggest that, in our study, the beneficial impact of the model change could not necessarily be improved by the addition of mandatory in-house intensivist presence at night. Certainly, the on-demand availability of an intensivist at night accompanied the model change, however, the impact of this change alone cannot be determined from our study.

In particular, our model change was associated with a reduced hospital LOS and a trend toward decreased in-hospital mortality. We did not see a significant difference in ICU LOS between the 2 groups. We surmise that the mechanisms behind this observation are multiple and difficult to delineate clearly. It is possible that death was prevented in some patients after the model change, which would result in longer ICU stays for those patients. In addition, some patients might have survived longer in the ICU and either eventually succumbed to their critical illness or were prevented from deterioration and development of organ failure. Conversely, the model change was almost certainly associated with faster extubation decisions in some patients. These various scenarios would have varying impacts on the ICU LOS and are impossible to sort out.

To our knowledge, the current study is one of very few to examine the impact of a model change in critical care delivery on rates of compliance with ICU process measures, such as timing of nutritional support, GI, and DVT prophylaxis. Kahn and colleagues[18] reported improvements in the use of ICU process measures such as DVT prophylaxis, stress ulcer prophylaxis, spontaneous breathing trial, interruption of sedation, and intensive insulin therapy by day 4 of mechanically ventilated patients who received care under a high-intensity critical care staffing model. One previous study in a pediatric intensive care unit population of patients,[19] examined several routine care modalities in a pre- and post-intensivist comparison, although nutrition and prophylaxis were not included in their analysis. They did, however, see significant increases in the use of gastrointestinal decompression, enteral feedings, and peripheral intravenous alimentation, in addition to decreased mortality in the post-intensivist group cohort of patients. Ghorra and colleagues[5] reported rates of the use of enteral feeding and parenteral nutrition, although they did not find a difference between the open and closed ICU models. In addition, they did not report the timing of initiation of the nutritional support in their study. Conversely, our study documents timing of the nutrition and prophylaxis, although it does not report overall rates, excluding those with a delay to therapy.

The finding of a trend toward decreased rates of timely initiation of GI prophylaxis was unanticipated. One would suspect that improvements in ICU organization attributed to intensivists would be reflected across several ICU process measures, even if they do not all yield significant differences. To see a trend in the opposite direction was unexpected. On reflection, we conclude that the results for GI prophylaxis must be interpreted with caution. We realized that patients who were discharged before our required time point but had prophylaxis documented were counted as having received GI prophylaxis. However, patients that did not have prophylaxis documented but were discharged from the ICU before our required time point were excluded. Therefore, the 2 groups, in this regard, might not be accurately represented. We acknowledge this as a limitation of this particular analysis.

Our most striking finding was that of markedly decreased in-hospital mortality in patients with sepsis. These findings, too, are congruent with earlier studies. In the early study by Li and colleagues,[1] patients with sepsis experienced a reduction in mortality from 92% to 61% with a switch to on-site physician staffing of the ICU. Similarly, Reynolds and colleagues[3] observed that dedicated critical care physician staffing was associated with a marked reduction in mortality in patients with septic shock managed by intensivists. However, in that study, overall mortality was markedly higher (74% "without" vs 57% "with" management by a group of board-certified intensivists, respectively) than in our study. This discrepancy could be related to a difference in severity of illness, as patients were included only if they met criteria for septic shock. However, the observed mortality in the group without critical care medicine (74%) was quite a bit higher than would be expected based on the mean APACHE II score (29 ± 11 compared with 28 ± 10 in the critical care medicine group). Li and colleagues did not calculate APACHE II scores in their study.

Our findings are limited by the small sample size of septic patients in both our pre- and post-intensivist cohorts, as was evident with our multivariate analysis, which did not retain the intensivists' benefit in mortality for septic patients. In addition, the small sample size likely contributed to baseline differences between the 2 groups, specifically APACHE II score. The higher APACHE II score in the pre-intensivist group suggests that this group of patients were sicker and were expected to have a higher mortality. However, as the APACHE II score reflects the first 24 hours after ICU admission, it is possible that the presence of intensivists led to better resuscitation and early management and an overall decrease in APACHE II score and fewer intubations. Although we certainly cannot prove this theory with the current study, it should at least be considered.

In addition, our ICU did not use a specific sepsis bundle protocol—as advocated by the Surviving Sepsis Campaign[20]—before or after the model change. There was no written protocol to manage sepsis, although elements of the sepsis bundle were included in the standard ICU admission orders after the model change. Consequently, there was no auditing of sepsis bundle compliance at either the 6- or 24-hour period. Although implementation of a sepsis bundle protocol might have impacted outcomes in our sepsis patient population had it existed, we cannot point to bundle compliance specifically as the source of the benefit of intensivists in our study. The benefit we observed in our study occurred in the absence of a specific sepsis protocol to care for our septic patients. We are unable to specifically address the paramount issue of source control in this study. A good deal of clinical judgment goes into determining when to operate on a patient or in determining the adequacy of source control, and this is impossible to abstract from the electronic medical record in a retrospective fashion.

There were several additional limitations to our study, aside from those already mentioned. First, patients during the 2 time periods were identified with the hospital's administrative database and although some data were abstracted that are likely to be quite valid, such as LOS, vital status at discharge, presence of mechanical ventilation, much of the data were abstracted from the clinical record, including presence of suspected infection at time of admission to ICU based on written progress notes by physicians. Written clinical notes also have a bias that is sometimes more difficult to manage than administrative databases, as most clinicians have not had standardized training compared with coders. Although this hospital had an electronic medical record with the capacity to document daily progress notes, only the intensivist service did this, and the other clinicians hand wrote progress notes on paper. This was until there was mandatory electronic documentation for all clinicians in 2011 (not captured in our study). Consequently, although the hospital administrative data have flaws, it is unlikely that the coding process will have changed between the 2 study groups.

Second, patient mix varied between the pre- and post-intensivist cohorts as a whole (fewer postoperative patients and more patients with respiratory failure), and not only in the subgroup analysis of septic patients (eg, baseline difference in APACHE II scores). Second, as with all studies that use the medical record, our study relied heavily on the accuracy of the documentation within the medical record, principally for the ICU process measures data. Differences in documentation practices or compliance between the 2 study periods could undoubtedly impact the results. It was lack of such documentation within the electronic medical record that caused us to discard one of our intended study end points—daily sedation holiday. We suspect that a lack of documentation might have played a role in the strikingly disparate results in mechanical DVT prophylaxis as well. Also, there was no distinction made between medical and surgical patients on nutritional support. Consequently, both groups might have included patients in whom nutritional support was not desirable during our designated time frame, which admittedly was an arbitrary selection. Finally, a before-and-after study cannot control for other secular trends in patient care that could improve patient outcomes but are independent of the new intensivist model.

To date, the exact mechanisms behind the impact of intensivists on outcomes in critically ill patients remains elusive. Whether it is the training and expertise of board-certified intensivists, increased access to these specialty-trained physicians, improved compliance with ICU protocols, or greater efficiency with multidisciplinary care teams, the beneficial impact of intensivists is clear. What has not and perhaps cannot be quantified is the change in the culture of safety within the ICU that accompanies a high-intensity staffing model. Undoubtedly, critically ill patients benefit from a shared mental model of patient care that is led by the consistent presence of specialists trained in critical care.

CONCLUSIONS

Our single-institutional retrospective study complements the existing literature that illustrates that ICU care models in which board-certified intensivists are involved in the management of critically ill patients is associated with improved outcomes, especially in septic patients. Although our study is the first to specifically demonstrate a change in ICU process measures such as prophylaxis, it does not link those measures to the outcomes shown. More studies are needed to explore intensivist management of critically ill patients and the associated benefit.

Author Contributions

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