Published in final edited form as:

Mayo Clin Proc. 2016 December ; 91(12): 1727–1734. doi:10.1016/j.mayocp.2016.08.004.

Impact of a Multidisciplinary Team Approach Including an Intensivist on the Outcomes of Critically Ill Patients in the Cardiac Care Unit

Zaher Fanari, MD, Armin Barekatain, MD, Roger Kerzner, MD, Sumaya Hammami, MD, MPH, William S. Weintraub, MD, and Vinay Maheshwari, MD

Division of Cardiovascular Diseases, University of Kansas School of Medicine, Kansas City, KS (Z.F., S.H.); and the Division of Cardiology (Z.F., A.B., R.K., W.S.W.), Value Institute (W.S.W.), and Division of Pulmonary and Critical Care (V.M.), Christiana Care Health System, Newark, DE

Abstract

Objective—To investigate the impact of integrating a medical intensivist into a cardiac care unit (CCU) multidisciplinary team on the outcomes of CCU patients.

Patients and Methods—We conducted a retrospective cohort study of 2239 CCU admissions between July 1, 2011, and July 1, 2013, which constituted patients admitted in the 12 months before and 12 months after the introduction of intensivists into the CCU multidisciplinary team. This team included a cardiologist, an intensivist, fellows and residents, CCU nurses, a pharmacist, and respiratory therapists. The primary outcome was CCU mortality. Secondary outcomes included hospital mortality, CCU length of stay, hospital length of stay, and duration of mechanical ventilation.

Results—After the implementation of a multidisciplinary team approach, there was a significant decrease in both adjusted CCU mortality (3.5% vs 5.9%; $P=.01$) and hospital mortality (4.4% vs 11.1%; $P<.01$). A similar impact was observed on adjusted mean CCU length of stay (2.5 ± 2.0 vs 2.9 ± 2.0 days; $P<.01$), adjusted mean hospital length of stay (7.0 ± 4.5 vs 7.5 ± 4.5 days; $P<.01$), and adjusted mean duration (2.0 ± 1.0 vs 4.3 ± 2.5 days; $P<.01$).

Conclusion—The implementation of a multidisciplinary team approach in which an intensivist and a cardiologist comanage the critical care of CCU patients is feasible and may result in better patient outcomes.

The role of the cardiac care unit (CCU) has evolved over time from a unit designed to care for patients after acute myocardial infarction (MI) with a focus on arrhythmia detection and hemodynamics to a more complex cardiac intensive care unit dealing with an increasingly diverse patient population, including patients with both complicated and uncomplicated MI, decompensated heart failure and frank cardiogenic shock, severe valvular heart disease,

Correspondence: Address to Zaher Fanari, MD, Division of Cardiovascular Diseases, University of Kansas School of Medicine, 3901 Rainbow Blvd, Kansas City, KS 66160, (zfanari@gmail.com).

SUPPLEMENTAL ONLINE MATERIAL

Supplemental material can be found online at <http://www.mayoclinicproceedings.org>. Supplemental material attached to journal articles has not been edited, and the authors take responsibility for the accuracy of all data.

high-grade conduction disturbances, refractory ventricular arrhythmias, complications of percutaneous procedures, and sequelae of intravascular device infections. The optimal care of these patient includes management of comorbidities,¹ especially in light of the substantial increase in the rate of sepsis and acute renal failure in the CCU population and the increase in the proportion of patients requiring mechanical ventilation, bronchoscopy, or renal replacement therapy during their CCU stay.^{2,3}

There is increasing evidence that intensivist staffing in critical care settings is associated with not only improvements in both intensive care unit (ICU) and hospital mortality but also with lower medical resource use.⁴⁻⁷ Evidence for decreased mortality has led to increased involvement of physicians trained in critical care in multidisciplinary care teams in both medical units and ICUs, a trend that has not been adopted to any notable extent in CCUs in the United States.¹

Given the breadth of critical illness and the remarkable patient diversity observed in our CCUs, we should anticipate an imminent challenge to the general cardiologists who currently staff these units. Therefore, we hypothesized that the addition of dedicated intensivists to a multidisciplinary team approach would assist in caring for critically ill patients with cardiovascular conditions and would lead to improved quality of care and patient outcomes in CCUs.

PATIENTS AND METHODS

Multidisciplinary Team Approach

A multidisciplinary team approach was considered standard care in our CCU before the intervention. This team consisted of cardiologists, cardiology fellows, medical residents, nurses, a respiratory therapist, and an ICU pharmacist. Critical care consultation was available and occurred on an ad hoc basis when more complex ventilation management was needed or if multiorgan failure developed. The rate of this consultation was 21%. Starting in July 2012, a formal program that integrated a board-certified medical intensivist with training in internal medicine and pulmonary/critical care into the daily management in the CCU at Christiana Hospital. There was no change in the cardiology staffing model before or after the intervention.

The role of the intensivist was to comanage patient care with the attending cardiologist. Responsibilities were delineated such that the intensivist primarily managed noncardiac issues, deferring primary cardiologic issues to the cardiologist. During multidisciplinary team rounds that included an intensivist, a daily checklist was utilized to ensure that important clinical issues regarding each patient were addressed. These items included assessments for any potential for harm to the patient, measures ensuring infection prevention, early mobility, and ventilator weaning readiness.

Additionally, a plan of care was developed and clearly articulated to all members of the health care team. There was no need to hire new intensivists during this approach; intensivists responsible for consultation outside the medical ICU managed their schedule to be available for the daily rounds and any potential additional need in the CCU after the daily

rounds. No other changes were introduced in attending cardiologist coverage, ICU triage, nurse shifts or ratios, or night coverage. Protocols to prevent central venous line and urinary catheter infections and hospital- and ventilator-acquired infections were already enforced as a part of the standard care before our intervention.

Data Collection, Study Population, and Outcomes

An electronic medical record review of patients admitted to the Christiana Care Health System CCU for 12 months before and 12 months after the integration of the intensivist into the cardiac care team was conducted. Christiana Care is a large system that comprises 2 hospitals with more than 1100 beds as well as a variety of outpatient and other services facilities. Christiana Care provides the majority of cardiovascular care in Delaware and the surrounding area, with an estimated 6000 diagnostic catheterizations, 1700 percutaneous interventions, 1800 electrophysiology laboratory procedures, 100 structural heart procedures, and 685 open heart surgical procedures annually. The CCU contains 12 beds and has a 2:1 nurse to patient ratio.

Two risk scores (the Acute Physiology and Chronic Health Evaluation III [APACHE III] and the Simplified Acute Physiology Score [SAPS II]) were used to risk stratify the patients before and after the intervention. The primary outcome was CCU mortality. Secondary outcomes included hospital mortality, CCU length of stay, hospital length of stay, and duration of mechanical ventilation.

Statistical Analyses

The Student *t* test for continuous variables (summarized as mean $\pm$ SD) and χ^2 test for categorical variables (summarized as number [%]) were used to compare baseline characteristics of patients before and after implementation of the new policy. Propensity scores to estimate the probability, on the basis of patient and hospital characteristics, that patients would be admitted to the CCU after implementation of the multidisciplinary protocol were developed with use of logistic regression to adjust for baseline characteristics of the patients and changes of hospital admission pattern before and after implementation of the new policy.^{8,9}

Patient-level covariates in the propensity model included age, sex, race, smoking status, history of coronary artery disease, diabetes, chronic and/or acute renal failure, hypertension, dyslipidemia, cerebrovascular disease, chronic lung disease, peripheral arterial disease, and heart failure, reason for admission (eg, ST-elevation MI, non-ST-elevation MI, sudden cardiac death, cardiogenic shock, heart failure exacerbation, cardiac arrest/ventricular arrhythmias), concomitant infections (eg, sepsis, central venous line infection, catheter-associated urinary tract infection), need for mechanical ventilation, duration of mechanical ventilation, and SAPS II and APACHE III scores. Hospital-level covariates included the annual volume of percutaneous interventions, annual volume of cardiac surgeons, and number of transfers from outside facilities. The continuous variable duration of mechanical ventilation was modeled as a linear trend.

Inverse probability weighting that was based on the propensity score was then used as the primary tool to adjust for differences between the 2 treatment groups. This approach, which was implemented to create balance, involved weighting each patient who was admitted before the multidisciplinary protocol by the inverse of the probability that he or she would be admitted after the multidisciplinary protocol and weighting each patient who was admitted after the multidisciplinary protocol by the inverse of the probability that he or she would be admitted before the multidisciplinary protocol. We verified the performance of the propensity model by comparing the distribution of covariates and propensity scores between treatment groups both before and after inverse probability weighting. Supplemental Table 1 (available online at <http://www.mayoclinicproceedings.org>) summarizes the unadjusted and inverse probability weighting adjustment. Sensitivity analysis was performed to account for possible misspecification of the propensity model and the impact of possible unmeasured confounders (Supplemental Figure, available online at <http://www.mayoclinicproceedings.org>). All tests were 2-tailed with $P<.05$ considered significant.¹⁰ We used SPSS for Windows, version 14.0 (SPSS Inc).

RESULTS

Between July 1, 2011, and July 1, 2013, 2239 patients were admitted to the CCU in our hospital, 820 in the 12 months before and 1419 in the 12 months after the introduction of the intensivist. Compared with patients admitted before the intervention, patients admitted after the intervention had greater morbidity, expressed by a higher mean APACHE III score (56.3 ± 12.1 vs 53.9 ± 13.3 ; $P<.01$) and SAPS II (44.8 ± 13.2 vs 41.5 ± 12.3 ; $P<.01$), and represented a higher rate of transferred patients as well as a higher incidence of intubated patients. However, the cohort after the intervention had a low rate of ST-elevation MI. The baseline characteristics of both groups are presented in Table 1. Depending on mortality risk calculated on the basis of the APACHE III score and SAPS II, patients were categorized as at low risk (mortality risk, $<10\%$), intermediate risk (mortality risk, $10\%–50\%$), and high risk (mortality risk, $>50\%$).

After the implementation of the new approach, there was a significant decrease in both adjusted CCU mortality (3.5% after vs 5.9% before intervention; $P=.01$) and adjusted hospital mortality (4.4% after vs 11.1% before; $P<.01$). Furthermore, there was also a significant reduction in adjusted mean CCU length of stay (2.5 ± 2.0 days after vs 2.9 ± 2.0 days before intervention; $P<.01$), adjusted mean hospital length of stay (7.0 ± 4.5 days after vs 7.5 ± 4.5 days before; $P<.01$), and adjusted mean ventilation duration (2.0 ± 1.0 days after vs 4.3 ± 2.5 days before; $P<.01$). Figure 1 illustrates the adjusted primary and secondary outcomes.

The reduction in mortality was not universal in all subgroups (Table 2). Although there was a nonsignificant difference in CCU mortality in low- and high-risk patients, there was a significant improvement in intermediate-risk patients (Table 2; $P<.01$ for interaction). The reduction in CCU length of stay was also not universal in all groups. Although it was not significant for low-risk patients, shorter length of stay was evident in both intermediate- and high-risk patients (Table 2; $P=.03$ for interaction). However, the reduction of ventilator days

in intubated patients was universal across all subgroups of risk (Table 2; $P<.01$ for interaction).

Using the APACHE III and SAPS II risk scores, we were able to predict each of these outcomes for both patient populations before and after the implementation of the multidisciplinary approach. We compared actual outcomes of each group to their respective predicted outcomes. Figure 2, A and B present 2 different comparisons; the first (Figure 2, A) compares the actual and predicted outcomes while applying a standard CCU approach, and the second (Figure 2, B) compares the actual and predicted outcomes while applying the intensivist comanagement approach. Using the standard approach (Figure 2, A), the actual outcomes were either comparable (hospital mortality), better (CCU mortality and CCU and hospital length of stay), or even slightly worse (ventilator duration). This trend was also noticed in the subgroups as well (Supplemental Table 2, available online at <http://www.mayoclinicproceedings.org>). Conversely, when compared with the predicted outcomes, the multidisciplinary approach (Figure 2, B) was associated with reduction in the primary and all secondary outcomes. This reduction was noticed in all subgroups (Supplemental Table 3, available online at <http://www.mayoclinicproceedings.org>). Table 3 compares the actual/predicted outcomes in all subgroups before and after the implementation of the multidisciplinary approach.

DISCUSSION

We have developed a CCU care model with a cardiologist, a medical intensivist, medical house staff, nurses, a pharmacist, a dietitian, and physical and respiratory therapists. In this study, the implementation of a formal program that allowed for the integration of a medical intensivist into the multidisciplinary team in the CCU was associated with significant reduction in both CCU and hospital mortality (both $P<.01$). Similarly, there was a significant reduction in CCU and hospital length of stay (both $P<.01$). This reduction was not seen in low-risk patients who did not have signs of multiorgan failure. Most of the improvements in mortality and length of stay rates were noticed in patients with higher APACHE III score, which put them at higher risk for mortality. These patients often have multiorgan failure, and early multilevel interventions may offer potential benefits over traditional standard of care. Our results reveal that the suggested model of a cardiologist and an intensivist comanaging critically ill cardiac patients is not only feasible but may also provide potential benefit in patient outcomes when applied in a multidisciplinary approach.

Since their introduction in the early 1960s, CCUs have played a pivotal role in reducing hospital mortality after MI, from 30% to 40% in the 1950s to 15% to 20% in the 1970s.¹¹ Prompt detection and treatment of peri-infarct arrhythmias were the focus of these early CCUs. Consequently, by 1980, the major cause of death related to MI had shifted from arrhythmias to ventricular failure.¹¹ Subsequently, there were many advances in monitoring techniques, treatment options, and interventions in the CCU. However, these advances were associated with only negligible subsequent improvements in the overall mortality rate in the CCU since the 1980s. This discrepancy was mainly explained by significant increases in noncardiovascular critical illness in the CCU patient population.²

There have been many changes in the demographic characteristics of the patients admitted to CCUs due to the aging of the US population and the coexistence of chronic illnesses, such as diabetes mellitus, hypertension, renal dysfunction, and obstructive lung disease, that have led to greater case mix and escalating illness severity.¹² Advances in technologies and improved therapeutics have led to increased survival from acute MI but have also increased length of stay secondary to greater exposure to invasive procedures and increased rates of iatrogenic complications, all resulting in amplified frequency and morbidity associated with multiorgan dysfunction during critical illness.¹ Moreover, studies have found a substantial increase in the rate of sepsis and acute renal failure complicating acute and chronic cardiovascular conditions in the CCU.² This problem has led to higher utilization of mechanical ventilation, bronchoscopy, or renal replacement therapy in the CCU over the past decade.^{2,3} As a result, the medical and procedural issues that determine outcome in the contemporary CCU are often the ones that require substantial expertise in critical care medicine. The benefit of intensivist management of ICU patients is more pronounced with a “closed high-intensity model” in which a single ICU-qualified physician manages the patients in comparison to an “open unit” in which individual admitting physicians manage the patients with consultants as needed.^{13,14}

The results of several nonrandomized studies support the notion that the inclusion of physicians trained in critical care in medical ICUs can not only improve patient outcomes but also improve medical resource use.^{4,5} There is evidence that this impact is probably explained in part by the presence of multidisciplinary teams in high-intensity physician-staffed ICUs.⁷ Similarly, surgical ICU data have documented that intensivist-driven ICU care is associated with a trend in mortality reduction when compared with an open ICU model.^{15,16} Kogan et al¹⁷ reported that adding quality improvement interventions to an intensivist-directed team model in the cardiothoracic surgery ICU was associated with more pronounced reduction of hospital mortality.¹⁷ Data from the neurologic ICU literature also confirm that introduction of the neurocritical care team is associated with reduced mortality and length of stay.¹⁸

However, although physicians trained in critical care medicine staff the vast majority of medical, surgical, and neurologic ICUs, that is not the case in CCUs in the United States.^{1,19} In a survey of 178 cardiac ICUs in the United States, data from 123 hospitals revealed that an intensivist consultation was available in only 46% of the ICUs caring for cardiac patients, and even in these sittings, intensivists were involved in the care of only 31.7% of intubated patients with cardiac conditions.¹⁹ The results of this survey illustrate that there is a real crisis in the field of cardiology critical care that should be addressed.¹

In response, the American Heart Association issued a scientific statement that acknowledged the basis of the problem, suggested potential models to risk stratify patients in the ICU, and proposed potential solutions to deal with this crisis.²⁰ Prediction models suggested to risk stratify patients in the CCU included the APACHE III, SAPS II, Mortality Probability Model, and Sequential Organ Failure Assessment.^{20–22} The scores from these models would identify patients at higher risk who may benefit the most from the multidisciplinary team approach suggested by the statement. Notably, none of these scores is well validated to risk stratify the CCU population because they do not adjust for specific characteristics such as

heart transplant and mechanical support. In the absence of specific CCU risk stratification scores, however, the current general ICU scores may offer an imperfect, but reasonable, alternative tool for risk assessment.

Regarding the critical care-trained physician deficit in the CCU, the statement suggested 1 of 3 staffing models. The first model is simply a unit in which cardiologists and a general intensivist comanage each patient or selected patients in the CCU. The second model depends on dedicated cardiac intensivists. The third model is structured to combine the CCU patients with surgical or medical ICU patients, producing a multidisciplinary unit that manages a very broad array of ICU patients.²⁰ Our study is the first, to our knowledge, that tests the potential benefits of any of these suggested models.

Our study has several limitations. First, it is a single-center study, and therefore, the results in our patient population may not be generalizable to all CCUs in the United States. Second, because it was a retrospective observational study comparing 2 different populations, there may be residual confounding between the 2 groups even after multivariate analysis. We sought to adjust for any residual patient differences by performing an inverse probability weighting analysis as well as comparing the actual outcomes of each group to the predicted outcomes based on the risk assessment. Furthermore, a randomized single-center trial testing this protocol may be quite challenging to conduct. The only feasible way is performing a multicenter trial using cluster randomization (in which randomization is performed at the level of the hospital, not at the level of individual patients). However, performing such a multicenter trial using cluster randomization will still be cumbersome and costly. Third, we used the APACHE III and SAPS II to risk stratify these patients and to predict the potential outcomes of each group.²⁰ Although these risk models are widely used in ICUs, they are not well validated in the CCU population. Finally, there may have been improvement between the 2 time periods due to other changes in care that probably led to the noticeable improvement of outcomes, including the daily checklist that led to better glycemic control, earlier initiation of enteral feeding, early mobility, and ventilator weaning readiness. Therefore, we were unable to identify the specific role of each of these changes in improving the quality of care.

Despite these limitations, this study represents novel information in the United States regarding the impact of a multidisciplinary team with an intensivist and a cardiologist comanaging patient care on the outcomes of patients in the CCU. These results are consistent with the expected benefit of such an approach, as has been documented in the setting of medical, surgical, and neurologic ICUs.^{7,10–13} Future studies may offer an insight on the applicability of this approach and sustainability of the results in different health system settings. Further economic assessment of this approach will be essential to help guide decision makers who may be interested in pursuing a similar approach.

CONCLUSION

The implementation of a multidisciplinary team approach in which an intensivist and a cardiologist comanage the critical care of patients in the CCU may reduce CCU and hospital mortality, CCU and hospital length of stay, and duration of mechanical ventilation.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

Grant Support:

This study was funded in part by an Institutional Development Award (IDeA) from the National Institute of General Medical Sciences of the National Institutes of Health under grant number U54-GM104941 (Primary Investigator: Stuart Binder-Macleod, PhD).

Abbreviations and Acronyms

APACHE III	Acute Physiology and Chronic Health Evaluation III
CCU	cardiac care unit
ICU	intensive care unit
MI	myocardial infarction
SAPS II	Simplified Acute Physiology Score

References

1. Katz JN, Turer AT, Becker RC. Cardiology and the critical care crisis: a perspective. *J Am Coll Cardiol.* 2007; 49(12):1279–1282. [PubMed: 17394958]
2. Katz JN, Shah BR, Volz EM, et al. Evolution of the coronary care unit: clinical characteristics and temporal trends in healthcare delivery and outcomes. *Crit Care Med.* 2010; 38(2):375–381. [PubMed: 20029344]
3. Valente S, Lazzeri C, Sori A, Giglioli C, Bernardo P, Gensini GF. The recent evolution of coronary care units into intensive cardiac care units: the experience of a tertiary center in Florence. *J Cardiovasc Med (Hagerstown).* 2007; 8(3):181–187. [PubMed: 17312435]
4. Brown JJ, Sullivan G. Effect on ICU mortality of a full-time critical care specialist. *Chest.* 1989; 96(1):127–129. [PubMed: 2736969]
5. Pollack MM, Katz RW, Ruttimann UE, Getson PR. Improving the outcome and efficiency of intensive care: the impact of an intensivist. *Crit Care Med.* 1988; 16(1):11–17. [PubMed: 3338276]
6. Pronovost PJ, Angus DC, Dorman T, Robinson KA, Dremsizov TT, Young TL. Physician staffing patterns and clinical outcomes in critically ill patients: a systematic review. *JAMA.* 2002; 288(17):2151–2162. [PubMed: 12413375]
7. Kim MM, Barnato AE, Angus DC, Fleisher LA, Kahn JM. The effect of multidisciplinary care teams on intensive care unit mortality. *Arch Intern Med.* 2010; 170(4):369–376. [PubMed: 20177041]
8. Sjölander A. Propensity scores and M-structures [letter]. *Stat Med.* 2009; 28(9):1416–1420. [PubMed: 19340845]
9. Curtis LH, Hammill BG, Eisenstein EL, Kramer JM, Anstrom KJ. Using inverse probability-weighted estimators in comparative effectiveness analyses with observational databases. *Med Care.* 2007; 45(10, suppl 2):S103–S107. [PubMed: 17909367]
10. Rosenbaum PR. Model-based direct adjustment. *J Am Stat Assoc.* 1987; 82(398):387–394.
11. Julian DG. The history of coronary care units. *Br Heart J.* 1987; 57(6):497–502. [PubMed: 3304366]

12. Quinn T, Weston C, Birkhead J, Walker L, Norris R, MINAP Steering Group. Redefining the coronary care unit: an observational study of patients admitted to hospital in England and Wales in 2003. *QJM*. 2005; 98(11):797–802. [PubMed: 16174687]
13. Carson SS, Stocking C, Podsadecki T, et al. Effects of organizational change in the medical intensive care unit of a teaching hospital: a comparison of ‘open’ and ‘closed’ formats. *JAMA*. 1996; 276(4):322–328. [PubMed: 8656546]
14. Multz AS, Chalfin DB, Samson IM, et al. A “closed” medical intensive care unit (MICU) improves resource utilization when compared with an “open” MICU. *Am J Respir Crit Care Med*. 1998; 157(5, pt 1):1468–1473. [PubMed: 9603125]
15. Nathens AB, Rivara FP, MacKenzie EJ, et al. The impact of an intensivist-model ICU on trauma-related mortality. *Ann Surg*. 2006; 244(4):545–554. [PubMed: 16998363]
16. Dimick JB, Pronovost PJ, Heitmiller RF, Lipsett PA. Intensive care unit physician staffing is associated with decreased length of stay, hospital cost, and complications after esophageal resection. *Crit Care Med*. 2001; 29(4):753–758. [PubMed: 11373463]
17. Kogan A, Preisman S, Berkenstadt H, et al. Evaluation of the impact of a quality improvement program and intensivist-directed ICU team on mortality after cardiac surgery. *J Cardiothorac Vasc Anesth*. 2013; 27(6):1194–1200. [PubMed: 24008163]
18. Suarez JJ, Zaidat OO, Suri MF, et al. Length of stay and mortality in neurocritically ill patients: impact of a specialized neurocritical care team. *Crit Care Med*. 2004; 32(11):2311–2317. [PubMed: 15640647]
19. O’Malley RG, Olenchok B, Bohula-May E, et al. Organization and staffing practices in US cardiac intensive care units: a survey on behalf of the American Heart Association Writing Group on the Evolution of Critical Care Cardiology. *Eur Heart J Acute Cardiovasc Care*. 2013; 2(1):3–8. [PubMed: 24062928]
20. Morrow DA, Fang JC, Fintel DJ, et al. American Heart Association Council on Cardiopulmonary, Critical Care, Perioperative and Resuscitation, Council on Clinical Cardiology, Council on Cardiovascular Nursing, and Council on Quality of Care and Outcomes Research. Evolution of critical care cardiology: transformation of the cardiovascular intensive care unit and the emerging need for new medical staffing and training models: a scientific statement from the American Heart Association. *Circulation*. 2012; 126(11):1408–1428. [PubMed: 22893607]
21. Breslow MJ, Badawi O. Severity scoring in the critically ill: part 1—interpretation and accuracy of outcome prediction scoring systems. *Chest*. 2012; 141(1):245–252. [PubMed: 22215834]
22. Minne L, Abu-Hanna A, de Jonge E. Evaluation of SOFA-based models for predicting mortality in the ICU: a systematic review. *Crit Care*. 2008; 12(6):R161. [PubMed: 19091120]

FIGURE 1.
Comparison of cardiac care unit (CCU) outcomes before and after the intervention.

FIGURE 2.

A, Comparison of actual and predicted cardiac care unit (CCU) outcomes while applying a standard approach. B, Comparison of actual and predicted ICU outcomes while applying a multidisciplinary approach including an intensivist.

TABLE 1

Unadjusted Baseline Characteristics of Patients Before and After the Intervention^{a,b}

Variable	Before intervention (N=820)	After intervention (N=1419)	P value
Age (y)	61.5±13.5	61.8±12.9	.59
Female	210 (25.6)	362 (25.5)	.64
Hypertension	640 (78.0)	1092 (77.0)	.31
Hyperlipidemia	658 (80.2)	1122 (79.1)	.29
Diabetes	274 (33.4)	515 (36.3)	.12
Current smoking	366 (44.6)	652 (45.9)	.87
Chronic obstructive pulmonary disease	137 (16.7)	273 (19.2)	.06
Chronic renal insufficiency	73 (8.9)	136 (9.6)	.57
Acute kidney injury	66 (8.0)	128 (9.0)	.53
Sepsis	74 (9.0)	137 (9.6)	.56
Outside hospital transfers	287 (35.0)	653 (46.0)	<.01
Catheter-associated urinary tract infections	1 (0.1)	1 (<0.1)	.70
Central line-associated bloodstream infections	3 (0.4)	1 (<0.1)	.15
Primary reason for CCU admission			
ST-elevation MI	188 (22.9)	274 (19.3)	<.01
Non-ST-elevation ACS	287 (35.0)	549 (38.7)	.09
Cardiac arrest/ventricular arrhythmias	89 (10.8)	142 (10.0)	.44
Nonischemic CHF with no shock	136 (16.6)	233 (16.4)	.44
Nonischemic CHF with shock	42 (5.1)	75 (5.3)	.78
Uncontrolled supraventricular arrhythmias	49 (6.0)	96 (6.8)	.58
Other	39 (4.8)	54 (3.8)	.87
SAPS II	41.5±12.3	44.8±13.2	<.01
APACHE III score	53.9±13.3	56.3±12.1	<.01
Low-risk patients	541 (66.0)	993 (70.0)	.06 ^c
Intermediate-risk patients	172 (21.0)	284 (20.0)	
High-risk patients	107 (13.0)	142 (10.0)	
Patients requiring ventilation	208 (25.4)	602 (42.4)	<.01
Low-risk patients	38/541 (7.0)	345/993 (34.7)	<.01
Intermediate-risk patients	82/172 (47.7)	156/284 (54.9)	.14
High-risk patients	88/107 (82.2)	101/142 (71.1)	.06

^aACS = acute coronary syndrome; APACHE III = Acute Physiology and Chronic Health Evaluation III; CCU = cardiac care unit; MI = myocardial infarction; SAPS = Simplified Acute Physiology Score.

^bData are presented as mean $\pm$ SD or No. (percentage) of patients.

^cThis *P* value with 2 degrees of freedom.

Author Manuscript

Author Manuscript

Author Manuscript

Author Manuscript

TABLE 2Comparison of CCU Outcomes in Different Risk Groups Before and After the Intervention^{a,b}

Variable		Before intervention (N=820)	After intervention (N=1419)	P value for interaction
Outcome	Mortality risk			
CCU mortality	Low	3/541 (0.6)	5/993 (0.5)	<.01
	Intermediate	19/172 (11.0)	16/284 (5.6)	
	High	26/107 (24.3)	29/142 (20.4)	
CCU length of stay (d)	Low	1.9±1.0	1.9±1.2	.03
	Intermediate	4.2±3.0	3.8±2.5	
	High	5.7±3.5	4.2±2.5	
Ventilation duration (d)	Low	3.1±2.5	1.4±1.0	<.01
	Intermediate	4.1±3.0	2.7±3.1	
	High	4.8±2.8	3.7±2.8	

^aCCU = cardiac care unit.^bData are presented as No. (percentage) of patients or mean ± SD.

TABLE 3

Comparison of Actual/Predicted CCU Outcomes Ratios in Different Risk Groups Before and After Applying a Multidisciplinary Approach Including an Intensivist

Variable		Actual/predicted CCU outcomes		P value
Outcome	Mortality risk	Before intervention	After intervention	
CCU mortality	Low	0.42	0.33	.03
	Intermediate	1.11	0.51	.01
	High	0.49	0.55	.69
CCU length of stay	Low	1.0	0.76	.01
	Intermediate	0.89	0.79	.03
	High	1.05	0.80	<.01
Ventilation duration (d)	Low	1.06	0.66	.01
	Intermediate	1.04	0.79	<.01
	High	1.33	0.86	<.01

CCU = cardiac care unit.