

Implementing Goal-Directed Protocols Reduces Length of Stay After Cardiac Surgery

Anne Miller, PhD,* Chad E. Wagner, MD,* Yanna Song, MS,† Kathleen Burns, RN,‡ Rashid Ahmad, MD,§
C. Lee Parmley, MD, JD,* and Matthew B. Weinger, MD*

Objective: To test the effect of a high reliability organization (HRO) intervention on patient lengths of stay in the CVICU and hospital. The authors proposed that (1) higher safety related evidence based protocol (SREBP) team compliance scores and (2) lower SREBP milestone scores are associated with shorter lengths of CVICU and hospital stay.

Design: A prospective, longitudinal observational evaluation was used to assess the effects of SREBP-focused rounding processes and a milestone-tracking tool.

Setting: United States, university academic medical center's 27-bed CVICU.

Participants: Six hundred sixty-five adult cardiac surgery patients and the CVICU care team (100 registered nurses and 16 clinical providers) participated.

Measurements and Main Results: Team compliance was the proportion of SREBP-related team behaviors exhibited during daily rounds. Patients' milestone scores were the cumulative difference between actual and expected times for 4 SREBP milestones over 48 hours. Milestones achieved

earlier than expected indicated reduced complication risk, and milestones achieved later than expected indicated increased risk. As team compliance increased, CVICU length of stay decreased 0.66 (95% CI: -0.04 to 1.28; $p = 0.08$) days; hospital stay decreased 0.89 times (95% CI: 0.77-1.03; $p = 0.008$). As the mean milestone scores increased from -7 to 12, length of ICU stay increased 2.63 (95% CI: 1.66-3.59; $p < 0.001$) days; hospital length of stay increased 1.44 times (95% CI: 1.23-1.7; $p = 0.05$).

Conclusions: A milestone-driven pathway supported by team rounding was associated with decreased lengths of CVICU and hospital stay. However, tracking patient trajectories by milestones suggests a more complex relationship than anticipated and presents new opportunities for SREBP implementation and research.

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KEY WORDS: cardiac surgery, quality improvement, intensive care, high reliability organizations, bundled payment

THE BENEFITS OF SAFETY-RELATED, evidence-based protocols (SREBP) in intensive care unit patients are well established for preventing ventilator-associated pneumonia (VAP),¹⁻⁵ ICU delirium,^{6,7} venous thromboemboli (VTE),^{8,9} catheter-associated bloodstream (CLABSI), and catheter-associated urinary tract infections (CAUTI).¹⁰⁻¹² However, despite widely disseminated protocols with well-documented decreases in length of stay,^{13,15} compliance rates as low as 10% and rarely greater than 50%¹⁶⁻¹⁸ are still reported; thus, the risks associated with these complications remain. This study's main objective was to evaluate the effects of using high reliability organization (HRO) approaches to implement a bundle for postoperative cardiac surgery patients.

Instead of monitoring task completion, HROs reliably achieve desired outcomes by tracking the occurrence of expected milestone events and adaptively modifying work processes and priorities in response to adverse deviations.¹⁹⁻²⁴ Increasingly, patient care is evolving toward routine and complex practice based on milestone event trajectories.^{13-18,33} In HROs, adaptation requires the collective sensitivity of front-line workers and managers to anticipate expected events, and it requires relationships among people that foster the communication and trust needed to anticipate and intervene on potentially adverse deviations.²⁴ Although HRO approaches have been implemented in some healthcare microsystems,²⁵⁻²⁷ healthcare organizations have struggled to translate HRO tools

and processes into sustained improvement with only a few documented successes.²⁸⁻³²

The present study was designed to evaluate HRO approaches for integrating complex SREBPs into routine care. Consistent with HRO approaches, the authors' interventions provide CVICU nursing and medical team members with a quantitative tool for prospectively tracking patient progress towards SREBP milestone events and an interdisciplinary team process for integrating outcome-oriented discussion into daily practice. This study does not evaluate the actual tasks that compose milestone events. These have been and will continue to be the subject of extensive research elsewhere.¹⁻¹² Consistent with other HRO approaches, the authors' interventions emphasize tool-supported, team-based, outcome-driven behaviors that support

From the *Departments of Anesthesiology and Critical Care, †Biostatistics, ‡Cardiovascular Intensive Care Unit, and §Cardiac Surgery, Vanderbilt University Medical Center, Nashville, TN.

Address reprint requests to Chad E. Wagner, MD, Vanderbilt University Medical Center, Department of Anesthesiology and Critical Care, 1211 21st Avenue South Suite 526 MAB, Nashville, TN 37212. E-mail: Chad.e.wagner@vanderbilt.edu

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coordinated patient care delivery.^{34–39} To evaluate these interventions, the authors tested the following primary hypotheses:

- H1: Higher team SREBP compliance scores are associated with shorter patient lengths of ICU and hospital stay.
 H2: Low milestone scores (milestones achieved earlier than expected, hence reduced risk of complications) are associated with shorter lengths of patient ICU and hospital stay.
 A secondary hypothesis included:
 H3: Patients with high milestone scores (delayed achievement and higher risk of complications) have higher levels of comorbidity than patients with low milestone scores.

METHODS

Following IRB approval, the study was conducted in a university academic medical center in the United States. The medical center's CVICU is a 27-bed unit that admits about 25 postcardiothoracic surgery patients per week. The unit has 2 care teams: Cardiothoracic/vascular surgery and cardiology. The authors studied the surgical team, which includes 8 midlevel providers and 8 intensivist attendings. Approximately 100 staff nurses manage cardiology and surgery patients on a 1:1-2 ratio depending on acuity.

Adult Cardiac Surgery Pathway Form

The pathway form was designed from a pre-existing, 7-page cardiac surgery pathway document developed by senior CVICU medical leadership and nursing staff. The research team, composed of senior medical and nursing practitioners and a human factors researcher, redesigned the original pathway document to improve its utility in daily practice. Preliminary drafts of the pathway phases, milestones, and other interventions were subjected to iterative feedback from physicians and nurses following short in-practice trials. During the trials, the researchers provided a one-on-one orientation to the pathway form to new staff and used this opportunity to elicit further feedback. This approach circumvented the need for an extensive education campaign.⁴⁰ New staff were introduced to the form and processes as part of their unit orientation.

Developing each phase's milestones required integrating dependencies across each of the SREBPs (VAP,^{1–5} Delirium,^{6,7} VTE,^{8,9} CABS, and CAUTI^{10–12}) to form a workflow-integrated, prospective, outcome-directed pathway,^{14,17,29–33} (See Goal and Intervention and Criteria sections in Appendix 1)]. This approach differs from previous research studies^{1–12} that viewed SREBPs as sets of independent tasks that are isolated from temporal and interdisciplinary dependencies.

The resulting pathway form (Appendix 1) was a single page, double-sided worksheet printed on yellow paper to enhance its visibility. The final worksheet was introduced into the CVICU on March 1, 2011. Bedside nurses could check off the tasks needed to achieve milestone outcomes. However, it was not mandatory that they do so, especially if outcomes were being achieved earlier than expected. The task checklist tended to serve a more effective role in diagnosing reasons for delayed goal achievement. Nurses were required to monitor and calculate milestone scores.

During twice-daily interdisciplinary rounds,^{34–36} nurses presented each patient's milestone score and status as on or off the pathway. If off pathway, nurses reported the major problem keeping the patient from progressing to the next milestone; the task checklist supported this assessment. The senior physician leading the round acknowledged the problem and discussed relevant mitigation strategies. The overall objective was to have patients ready for transfer from the CVICU to the step-down unit within 48 hours following stabilization.

Postsurgical stabilization is variable. Some patients are physiologically stable on CVICU arrival; others stabilize after some hours, and a

small number of patients remain unstable for days. Patients were excluded from further participation if they were not physiologically stable within 48 hours of CVICU admission. Such patients were assessed as requiring a non-routine postsurgical pathway.

When physiologic stability was achieved (defined as the point at which the patient was neurologically intact, not on a peep greater than 8 and/or F_{iO_2} greater than 0.4, escalating doses of vasopressors, or a rising or unexplained lactate), the time was declared to be time zero and written beneath the stabilization phase. Expected phase achievement times were calculated in 6-hour intervals from time zero for the first 24 hours and then in 24-hour intervals until 48 hours after stabilization. The decision to use 6-hour intervals was based on clinical experience informed by evidence.^{1–12}

The time a phase actually was achieved was noted beneath the expected time. Milestone scores were calculated by subtracting the actual achievement time from the expected time. A negative sign was given to the score indicating that a phase milestone was achieved earlier than the expected time, thus reducing SREBP complication risk, whereas a positive sign indicated a phase milestone achieved later than the expected time potentially increasing SREBP complication risk. Cumulative milestone scores indicated overall progress. The back of the worksheet was used for explanatory notes and further instruction.

SREBP Team Compliance

A trained research assistant joined all weekday morning and most afternoon rounds from March through August 2011 and from December 2011 through February 2012 to record team compliance using the team compliance worksheet. Afternoon rounds did not always occur due to competing priorities and other pressures, so some afternoon compliance data could not be included. The research assistant did not attend rounds between September and November 2011 to assess any observer effects. The same research assistant participated throughout the study.

These interventions are consistent with the following HRO principles:²⁴ (1) Improve sensitivity to current operational outcomes. The prospective pathway form emphasized milestone outcomes (extubation, decatheterization) as the criteria for evaluating patient progress. The Interventions and Achievement Criteria checklists in Appendix 1 could be helpful in diagnosing team or patient reasons for a patient's failure to progress. (2) Sensitivity to relationships. The longitudinal trajectory of care spans work shifts. Along with the inclusion of pathway status in major daily rounds, this emphasizes the continuous and team nature of care delivery. Daily inclusion in rounds was important in diagnosing reasons for failure to progress as either patient deterioration or deficits in team behavior and for considering changes in care.

Data Analysis

Hypotheses 1 and 2 were addressed by fitting regression models for patients' lengths of ICU and hospital stay to mean cumulative milestone and team compliance scores. Potential patient confounding variables (Table 1) were prespecified and included in modeling along with the independent variables. A log transformation was applied to hospital length of stay to meet normality and constant variance assumptions. To allow the nonlinearity of continuous covariates, linear tail-restricted cubic spline with three knots were used.⁴² Quantile regression models with the same patient covariates were fitted to ICU length of stay because no suitable transformation was found. Unlike ordinary least squares regression models, quantile regression estimates the median (or other quantiles) of the dependent variables instead of the mean without making normality and equal variance assumptions.⁴² Missing data were handled by complete case analysis and multiple imputation method.⁴¹ Because conclusions based on these 2 methods were not significantly different, results reported in this paper were based on complete case analysis. To test hypothesis 3, the authors

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