Improved Outcomes Associated With a Revised Quality Measure for Continuing Perioperative β-Blockade

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**IMPORTANCE** The Surgical Care Improvement Project perioperative β-blocker (BB) (SCIP-BB) continuation measure was revised in 2012 to incorporate inpatient BB continuation after discharge from the postanesthesia care unit.

**OBJECTIVE** To determine whether adherence to the original or revised SCIP-BB measure is associated with decreased adverse events.

**DESIGN, SETTING, AND PARTICIPANTS** Retrospective cohort study using national Veterans Affairs patient-level data on adherence to the original SCIP-BB measure and inpatient BB continuation for operations between July 2006 and August 2009.

**METHODS** Data for SCIP-BB measure adherence, inpatient BB continuation, and patient and procedure risk variables were used to estimate the associations between adherence to the original and revised SCIP-BB measures and outcomes of major adverse cardiovascular or cerebrovascular events (MACCEs) and their components of cardiovascular events, cerebrovascular events, and 30-day mortality. In addition to unadjusted estimates, propensity score matching and bootstrapping were used to estimate the associations and generate 95% CIs.

**MAIN OUTCOMES AND MEASURES** Major adverse cardiovascular or cerebrovascular events.

**RESULTS** Of 14,420 nonemergent operations with at least 2 postoperative inpatient days, 13,170 (91.3%) adhered to the original SCIP-BB measure, and 480 (3.3%) experienced a MACCE. Propensity score–matched analyses showed that adherence to the original SCIP-BB measure was not associated with MACCEs (odds ratio [OR], 1.00; 95% CI, 0.66-1.54) but was associated with increased cerebrovascular events (OR, 3.01; 95% CI, 1.00-10.07). Adherence to the revised SCIP-BB measure occurred in 11,597 (80.4%), and in matched analysis adherence was associated with decreased MACCEs (OR, 0.75; 95% CI, 0.57-0.95), cardiovascular events (OR, 0.66; 95% CI, 0.46-0.93), and 30-day mortality (OR, 0.74; 95% CI, 0.53-0.98). Adherence to the revised SCIP-BB measure was not associated with increased cerebrovascular events (OR, 1.22; 95% CI, 0.62-2.38).

**CONCLUSIONS AND RELEVANCE** Adherence to the original SCIP-BB measure was associated with increased cerebrovascular events but not improved cardiovascular event outcomes. β-Blocker continuation consistent with the revised SCIP-BB measure is associated with reduced MACCEs, cardiovascular events, and 30-day mortality. These data provide a cautionary tale of implementing performance measures before they have been rigorously tested. Although the observed associations between adherence to the revised SCIP-BB measure and outcomes are promising, they should be evaluated in the postimplementation period.
The Surgical Care Improvement Project (SCIP) measures whether chronic perioperative β-blocker (BB) therapy was continued or a reason for withholding therapy was documented. The original SCIP-BB measure was instituted in 2005, and the perioperative period was defined as extending from 24 hours before incision to discharge from the postanesthesia care unit. Effective July 2012, the SCIP-BB measure was revised, extending the perioperative period to include the first 2 postoperative days. However, no study to date has evaluated whether adherence to the original SCIP-BB measure is associated with improved surgical outcomes. Evidence for perioperative BB effectiveness is inconsistent, and results of studies suggest that the consequences of perioperative BB use are mixed, with cardioprotection possibly at the expense of increased risk of other adverse events.

The primary objective of this study was to examine the associations between adherence to the original SCIP-BB measure and surgical outcomes in a national Veterans Affairs (VA) cohort, including a broad range of noncardiac surgical procedures. We hypothesized that measure adherence would be associated with decreased cardiovascular and cerebrovascular events, 30-day mortality, and the composite of those 3 adverse outcomes, namely, major adverse cardiovascular or cerebrovascular events (MACCEs). As a secondary analysis, we assessed the association between surgical outcomes and postoperative BB continuation consistent with adherence to the revised SCIP-BB measure. We hypothesized that continuation consistent with the revised SCIP-BB measure would be associated with a further decrease in MACCEs.

**Methods**

**Overview**

The study protocol was reviewed and approved by the Birmingham Veterans Affairs Medical Center Research and Development Committee and the Institutional Review Board, as well as by the VA Surgical Quality Data Use Group and the VA Office of Information and Analytics in the VA central office, Washington, DC. As a retrospective study using previously collected data, the requirement for informed consent was waived by the institutional review board. We conducted a retrospective cohort study of surgical procedures meeting criteria for the SCIP-BB measure between July 2006 and August 2009 in the VA system to study the associations between SCIP-BB measure adherence and surgical outcomes. National VA SCIP data were matched to the VA Surgical Quality Improvement Program (VASQIP). Additional pharmacy and vital sign data were merged from the VA's electronic health records documenting inpatient BB continuation and possible contraindications.

**Data Sources**

The VA Office of Information and Analytics External Peer Review Program contracts with the West Virginia Medical Institute, Charleston, to collect VA hospital SCIP measures. The VA began collecting data on SCIP measures for a sample of eligible surgical procedures in 2005 according to guidelines set forth by The Joint Commission and the Centers for Medicaid & Medicare Services. The VASQIP began in 1991 to analyze risk-adjusted 30-day postoperative morbidity and mortality data within the VA health care system, and its methods have been previously published. A 2007 study of the quality of the VASQIP data at a sample of VA medical centers showed that the data were complete and had high reliability.

**Patient Sample**

The study population eligible for the SCIP-BB measure includes all patients currently receiving BB therapy and undergoing noncardiac surgical procedures. In total, 16 874 non-emergent procedures were identified; our main analytical cohort was restricted to 14 420 patients with a postoperative inpatient stay of at least 2 days, allowing evaluation of the original and revised SCIP-BB measure.

**Study Variables**

The main independent variable was adherence to the original SCIP-BB measure. The original measure definition required documentation that the patient received BB therapy within the perioperative period, defined as 24 hours before incision through postanesthesia care unit discharge (including patient self-report of BB use for same-day admissions), or documentation of a reason for withholding BB therapy. The independent variable for the secondary analysis was adherence to a calculated version of the revised SCIP-BB measure that went into effect in July 2012. The revised SCIP-BB measure extends the perioperative period to the first 2 inpatient postoperative days and requires adherence to the original measure, as well as BB continuation on at least 1 of the first 2 postoperative days or a documented reason for withholding. The revised SCIP-BB measure was constructed using adherence to the original SCIP-BB measure and inpatient pharmacy data for postoperative days 1 and 2 (Figure 1).

Our main outcome was the occurrence of MACCEs within the 30-day postoperative period. Major adverse cardiovascular or cerebrovascular events include any major cardiovascular event (myocardial infarction or cardiac arrest), any cerebrovascular event (cerebrovascular accident or coma), or 30-day mortality based on the VASQIP-assessed outcomes. Secondary outcomes analyses considered the individual MACCE components separately.

Patient-level covariates obtained from the VASQIP included demographics, tobacco use, alcohol use, and comorbidities. Serum albumin, bilirubin, and creatinine laboratory values closest to the time of the operation are often missing when tests were not ordered. We created indicator variables to code whether laboratory values were present. Surgery characteristics considered included length of operation, American Society of Anesthesiologists classification, wound status (clean, clean and contaminated, contaminated or dirty, or infected), and Current Procedural Terminology category (abdominal, endocrine, hernia, integumentary and musculoskeletal, oropharynx, respiratory and hematologic, cardiovascular, or vascular thoracic). To account for the complexity of the operation, the VASQIP collected work relative-value unit, a component of the
Continuing Perioperative β-Blockade

resource-based relative-value unit that is linked only to Current Procedural Terminology codes. The Revised Cardiac Risk Index was constructed using the VASQIP data and VA records to account for baseline cardiac risk. The Revised Cardiac Risk Index was then used to categorize individuals as having 0, 1, 2, or 3 or more factors.

Statistical Analysis
χ² Tests and t tests were used for unadjusted associations. Propensity score matching was used to control for confounding in estimating the associations of SCIP-BB measure adherence (original and revised) with study outcomes. These analyses were repeated stratified by the Revised Cardiac Risk Index to explore which patients may benefit from measure adherence. Separate propensity scores were constructed for each comparison using classification trees, with the minimum node size set to 100 to avoid overfitting. All variables considered for and incorporated into the propensity scores are listed in eTable 1 in the Supplement. For each exposure comparison, individuals in the smaller group were randomly matched 1 to 1 to individuals in the larger group within the same terminal node of the tree. Following the method by Austin, marginal associations were estimated by logistic regression with generalized estimating equations to account for the matched pairing. Matching and estimation were repeated with 1000 bootstrapped replicates of the original data set to generate empirical 95% CIs. All matched analyses were repeated using propensity scores estimated by logistic regression. Statistical software packages (SAS version 9.2; SAS Institute Inc and R version 2.15.2; http://cran.r-project.org/bin/windows/base/old/2.15.2/) were used for data set preparation and analysis.\textsuperscript{13-15}

We performed several sensitivity analyses to further clarify the association between SCIP-BB measure adherence and MACCEs. First, to understand the differences observed between adherence to the 2 versions of the SCIP-BB measure, we compared outcomes between the group adherent to the original SCIP-BB measure but not to the revised SCIP-BB measure with those adherent to the revised SCIP-BB measure. Second, we repeated the analyses after restricting the cohort to patients for whom BB continuation was “appropriate,” constructed by excluding patients with any documented inpatient systolic blood pressure of less than 100 mm Hg or a heart rate of less than 50 beats/min in the first 2 postoperative days.\textsuperscript{6} Third, to ascertain whether nonadherence may have followed a MACCE, we calculated unadjusted event rates and odds ratios (ORs), excluding observations with any MACCE on the day of surgery for the original SCIP-BB measure and any MACCE occurring before the second postoperative day for the revised SCIP-BB measure cohorts.

Results
In total, 14,420 surgical cases with original SCIP-BB measure and VASQIP data and a postoperative stay of at least 2 days were included in the study cohort. Some patients with more than 1 VASQIP-assessed surgical procedure were included more than once. The demographics, comorbidities, and procedure characteristics of the study population stratified by original and revised SCIP-BB measure adherence are summarized in the Table. Overall, 13,170 of 14,420 individuals (91.3%) adhered to the original SCIP-BB measure, and 11,597 (80.4%) had BB continuation consistent with the revised SCIP-BB measure (Figure 1). Four hundred eighty (3.3%) experienced a MACCE. Several factors were significantly associated with the original or revised SCIP-BB measure adherence in unadjusted testing. In general, comorbidities, lower functional status, and higher American Society of Anesthesiologists classification were associated with adherence. eTable 2 in the Supplement lists selected patient and operative characteristics by measure adherence for 100 aggregated bootstrapped, matched data sets and reflects the improved balance due to matching.

The associations of SCIP-BB measure adherence with study outcomes are summarized in Figure 2 as the number and proportion of events, with unadjusted ORs and ORs from bootstrapped, matched analyses shown as a forest plot. In unadjusted analyses, adherence to the original SCIP-BB measure was associated with increased risk of cerebrovascular events (OR, 4.20; 95% CI, 1.03-17.07) but not with any of the other study outcomes at the level of \( P < .05 \). Adherence to the revised SCIP-BB measure was associated with a decreased risk of MACCEs (OR, 0.65; 95% CI, 0.52-0.79), cardiovascular events (OR, 0.57; 95% CI, 0.43-0.76), and 30-day mortality (OR, 0.61; 95% CI, 0.47-0.78). No association was found between adherence to the revised SCIP-BB measure and risk of cerebrovascular events. Results of the matched analyses are generally consistent with the unadjusted results (Figure 2). The same analyses for the composite MACCE outcome stratified by the Revised Cardiac Risk Index are summarized in Figure 3. Although power is limited for the stratified analysis, the forest
The plot suggests that as cardiac risk increases the protective association with SCIP-BB measure adherence increases.

Subgroup analyses compared those adherent to the original SCIP-BB measure but not to the revised measure (n = 1573) (ie, with postoperative BB discontinuation) vs those adherent to the revised SCIP-BB measure. In unadjusted analyses, this subgroup had increased rates of MACCEs (96 [6.1%]; OR, 2.09; 95% CI, 1.66-2.64), cardiovascular events (51 [3.2%]; OR,
Continuing Perioperative β-Blockade

Figure 2. Unadjusted and Propensity Score–Matched Associations Between SCIP-BB Measure Adherence and Study Outcomes

<table>
<thead>
<tr>
<th></th>
<th>Nonadherent</th>
<th>Adherent</th>
<th>Unadjusted OR (95% CI)</th>
<th>PS Matched OR (Adherent vs Nonadherent)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Original SCIP-BB Outcome</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MACCE</td>
<td>34 (2.7)</td>
<td>446 (3.4)</td>
<td>1.25 (0.88-1.79)</td>
<td>1.00 (0.66-1.54)</td>
</tr>
<tr>
<td>Cardiovascular event</td>
<td>18 (1.4)</td>
<td>215 (1.6)</td>
<td>1.14 (0.70-1.84)</td>
<td>0.90 (0.52-1.68)</td>
</tr>
<tr>
<td>Cerebrovascular event</td>
<td>2 (0.2)</td>
<td>88 (0.7)</td>
<td>4.20 (1.03-17.07)</td>
<td>3.01 (1.00-10.07)</td>
</tr>
<tr>
<td>30-d Mortality</td>
<td>24 (1.9)</td>
<td>282 (2.1)</td>
<td>1.12 (0.73-1.70)</td>
<td>0.91 (0.53-1.51)</td>
</tr>
<tr>
<td><strong>Revised SCIP-BB Outcome</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MACCE</td>
<td>130 (4.6)</td>
<td>350 (3.0)</td>
<td>0.65 (0.53-0.79)</td>
<td>0.75 (0.57-0.95)</td>
</tr>
<tr>
<td>Cardiovascular event</td>
<td>69 (2.4)</td>
<td>169 (1.5)</td>
<td>0.57 (0.43-0.76)</td>
<td>0.66 (0.46-0.93)</td>
</tr>
<tr>
<td>Cerebrovascular event</td>
<td>16 (0.6)</td>
<td>74 (0.6)</td>
<td>1.13 (0.66-1.93)</td>
<td>1.22 (0.62-2.38)</td>
</tr>
<tr>
<td>30-d Mortality</td>
<td>87 (3.1)</td>
<td>219 (1.9)</td>
<td>0.61 (0.47-0.78)</td>
<td>0.74 (0.53-0.98)</td>
</tr>
</tbody>
</table>

Figure 3. Unadjusted and Propensity Score–Matched Associations Between SCIP-BB Measure Adherence and MACCEs Stratified by the RCRI

<table>
<thead>
<tr>
<th></th>
<th>Nonadherent</th>
<th>Adherent</th>
<th>Unadjusted OR (95% CI)</th>
<th>PS Matched OR (Adherent vs Nonadherent)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Original SCIP-BB RCRI</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>1 (0.3)</td>
<td>28 (0.9)</td>
<td>3.17 (0.43-23.35)</td>
<td>2.01 (0.50-6.07)</td>
</tr>
<tr>
<td>1</td>
<td>8 (1.7)</td>
<td>133 (2.7)</td>
<td>1.55 (0.76-3.19)</td>
<td>1.20 (0.49-2.92)</td>
</tr>
<tr>
<td>2</td>
<td>11 (4.0)</td>
<td>149 (4.7)</td>
<td>1.19 (0.64-2.23)</td>
<td>1.00 (0.49-2.23)</td>
</tr>
<tr>
<td>≥3</td>
<td>14 (9.2)</td>
<td>136 (7.5)</td>
<td>0.80 (0.45-1.43)</td>
<td>0.71 (0.31-1.46)</td>
</tr>
<tr>
<td><strong>Revised SCIP-BB RCRI</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>9 (1.5)</td>
<td>20 (0.7)</td>
<td>0.45 (0.20-0.99)</td>
<td>0.43 (0.11-1.20)</td>
</tr>
<tr>
<td>1</td>
<td>34 (3.1)</td>
<td>107 (2.5)</td>
<td>0.80 (0.54-1.18)</td>
<td>0.84 (0.52-1.27)</td>
</tr>
<tr>
<td>2</td>
<td>41 (5.9)</td>
<td>119 (4.3)</td>
<td>0.72 (0.50-1.03)</td>
<td>0.73 (0.45-1.11)</td>
</tr>
<tr>
<td>≥3</td>
<td>46 (10.9)</td>
<td>104 (6.7)</td>
<td>0.58 (0.41-0.84)</td>
<td>0.59 (0.39-0.91)</td>
</tr>
</tbody>
</table>

2.34; 95% CI, 1.70-3.21), and 30-day mortality (63 [4.0%]; OR, 2.17; 95% CI, 1.63-2.88) but no significant association with cerebrovascular events. Matched analyses showed increased risk of MACCEs (OR, 1.41; 95% CI, 1.07-1.83) and cardiovascular events (OR, 1.68; 95% CI, 1.12-2.48). Results of the sensitivity analyses are summarized in the Supplement. Analyses limited to the appropriate cohort without potential contraindications to BB continuation are shown in eFigure 1 in the Supplement. Continuation consistent with the revised measure in this appropriate cohort was 79.9%. Point estimates are consistent with the main analyses. Adherence to the original SCIP-BB measure is no longer significantly associated with cerebrovascular events, while adherence to the revised SCIP-BB measure remains associated with significantly reduced risk of MACCEs, cardiovascular events, and 30-day mortality.

Analyses that excluded observations with early MACCEs are shown in eFigure 2 in the Supplement. For the original SCIP-BB measure, 4.0% (n = 18) of all MACCE events among those adherent occurred on the day of surgery, while 5.9% (n = 2) of all MACCE events were early among those nonadherent (P = .94). For the revised SCIP-BB measure, the proportion of MACCEs that occurred before the second postoperative day was 11.4% (n = 40) for the adherent and 18.5% (n = 24) for the nonadherent (P = .06). Unadjusted results are again consistent with the main findings.

Discussion

This study examined the associations between adherence to the original SCIP-BB quality measure and surgical outcomes. Secondary analyses examined the associations with a calculated revised SCIP-BB measure that extended the perioperative period to include the first 2 postoperative days. The main finding is that adherence to the original SCIP-BB measure is associated with increased risk of cerebrovascular events but no decrease in MACCEs, cardiovascular events, or 30-day mortality, while adherence to the revised SCIP-BB measure is associated with decreased rates of MACCEs, cardiovascular events, and 30-day mortality. To our knowledge, no other study to date has evaluated the associations between SCIP-BB measure adherence and surgical outcomes.

Most existing studies of perioperative BB use have focused on BB initiation (eg, the Perioperative Ischemic Evaluation trial) or BB use without distinguishing initiation and continuation. However, a few studies have explicitly con-
sidered perioperative BB continuation among patients receiving chronic preoperative BB therapy. One is a large single-center VA study by Wallace et al. Consistent with our findings, they identified an association between postoperative discontinuation and increased mortality. Another recent study by Kwon and colleagues studied BB continuation among 1976 patients prescribed BBs before surgery and undergoing bariatric and colorectal procedures. They studied BB continuation both during the same window as the original SCIP-BB measure (24 hours before incision to postanesthesia care unit discharge) and on the first postoperative day. Their observed continuation rate was 66%, with a significant association between incomplete continuation and increased adverse events within 30 days (OR, 2.10; 95% CI, 1.15-3.84). In secondary analyses, they found increased risk when the BB was not given in concordance with the original SCIP-BB measure (OR, 2.02; 95% CI, 1.15-3.78) but no association when the BB was not given after surgery (OR, 0.80; 95% CI, 0.17-3.69). This contrasts with our findings and those by Wallace et al of increased risk with postoperative BB discontinuation. These discordant findings may be explained by demographic and surgical differences among our cohorts, continuation rates, and the periods considered relative to surgery. However, the discrepancies suggest the need for more careful and detailed study of the associations between perioperative BB continuation patterns and outcomes.

A recent study by London et al examined BB use on the day of surgery or the first day after surgery in a large national VA cohort of the VASQIP-assessed surgical procedures (n = 136,745). In agreement with other studies, notably results reported by Lindenauer et al, they found decreased rates of cardiac complications and mortality among patients exposed to BBs on either day. In contrast to our study, the study by London et al was limited to patients admitted on the day of surgery, it included patients not receiving BBs before surgery, and BB exposure was identified only by inpatient pharmacy records. Therefore, their study could not capture intraoperative or patient self-administered BB exposure on the day of surgery.

Our findings suggest increased risk of adverse events among patients with postoperative BB discontinuation. The exclusive focus of the original SCIP-BB measure on continuation only through postanesthesia care unit discharge may have contributed to postoperative discontinuation by de-emphasizing the postoperative days. This is evidenced by 91.3% adherence to the original measure, while postoperative continuation was 80.4%, a difference not explained by appropriate withholding secondary to abnormal vital signs (79.9% continuation in the appropriate cohort). The matched analyses suggest that the risk associated with discontinuation is due to the discontinuation itself, but results are not definitive.

This study has considerable strengths, including its large national sample, range of procedures, official data for adherence to the original SCIP-BB measure, validated outcomes, and high-quality clinical data with exposure and outcome assessed by different programs. It also has important limitations. Because it includes only VA cases, patients were more often male, white, and older than the wider surgical population. A general methodologic limitation is that observational studies are subject to confounding. Propensity scores can only account for confounding due to measured factors, and unmeasured factors correlated with measured confounders to a limited extent.

Another limitation is the rarity of some adverse events, which renders modeling problematic. While the most striking finding was increased cerebrovascular events with adherence to the original SCIP-BB measure, only 2 cerebrovascular events occurred among patients with nonadherent care. However, this limitation is shared by the studies used as evidence for the measure itself.

To address appropriate withholding of BB, we constructed an appropriate cohort that excluded patients with bradycardia or hypotension. However, we could not distinguish whether such contraindications were responses to administering BB or reasons for withholding therapy. Consequently, this cohort restriction may be overly conservative.

**Conclusions**

We observed no association between adherence to the original SCIP-BB measure and MACCE outcomes with the exception of increased risk of cerebrovascular events. In contrast, we found robust protective associations of BB continuation consistent with adherence to the revised SCIP-BB measure and MACCEs, cardiovascular events, and 30-day mortality. Further studies should ascertain whether adherence to the revised SCIP-BB measure remains associated with improved outcomes in the postimplementation period.

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**Author Contributions:** Drs Richman and Hawn had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. Study concept and design: Richman, Itani, Hawn. Acquisition, analysis, or interpretation of data: Richman, Deierhoi, Henderson, Hawn. Drafting of the manuscript: Richman. Critical revision of the manuscript for important intellectual content: Itani, Henderson, Hawn. Statistical analysis: Richman. Obtaining funding: Richman, Hawn. Administrative, technical, or material support: Deierhoi.

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REFERENCES


