
Multivariable Predictors of Postoperative Cardiac Adverse Events after General and Vascular Surgery: Results from the Patient Safety in Surgery Study

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- BACKGROUND:** Cardiac adverse events (CAEs) are relatively infrequent, but highly lethal, after noncardiac operations. The value of available risk scoring systems is uncertain and these systems can be outdated. We used the Patient Safety in Surgery Study database to develop and test a model to predict patient risk for CAEs after general and vascular surgical operations.
- STUDY DESIGN:** As part of the Patient Safety in Surgery Study, following the National Surgical Quality Improvement Program's protocol, multiple demographic, preoperative, perioperative, and outcomes variables were measured during a 3-year period. Data from 128 Veterans Affairs medical center hospitals and from 14 academic medical centers on 183,069 patients were used in a logistic regression analysis to model multivariable predictors of serious CAEs (cardiac arrest or acute myocardial infarction within 30 days of operation).
- RESULTS:** CAEs occurred in 2,362 patients (1.29%) and of these, 59.44% expired. Multivariable stepwise logistic regression identified 20 independent predictors of CAEs, which excluded most cardiac-specific risk factors. The most important multivariable predictors of CAE were American Society of Anesthesiologists physical status classification, work relative value units of the most complex procedure, age, and type of operation. A risk prediction scoring system using the logistic regression odds ratios proved to be a useful prediction tool when tested using a random sample from the database.
- CONCLUSIONS:** CAEs after noncardiac operations are relatively infrequent but highly lethal. Operation type and urgency and American Society of Anesthesiologists physical status assessment are important independent predictors of cardiac morbidity, but angina, recent MI, and earlier cardiac operation are not. A prediction scoring system based on the Patient Safety in Surgery Study multivariable odds ratios is likely to be predictive of future events in a similar population requiring noncardiac procedures. This risk model can also serve as a tool to measure quality and effectiveness of care by providers who perform noncardiac operations. (*J Am Coll Surg* 2007;204:1199–1210. © 2007 by the American College of Surgeons)
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Cardiac adverse events (CAEs) after noncardiac operations are potentially lethal, although infrequent. They are the most common cause of serious perioperative

morbidity and mortality in patients undergoing noncardiac operations.¹ These complications are reported in 1% to 5% of patients undergoing noncardiac opera-

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Abbreviations and Acronyms

ASA	= American Society of Anesthesiologists
CAE	= cardiac adverse event
CPT	= current procedural terminology
NSQIP	= National Surgical Quality Improvement Program
PSS	= Patient Safety in Surgery
RVU	= relative value unit
VA	= Veterans Affairs

tions.^{2,3} In 1 recent study, the incidence of a serious cardiac event in consecutive patients during a 3-month period was 1% to 2%, with CAEs more common in patients older than 75 years of age, diabetics, hypertensives, and patients with baseline ECG abnormalities suggesting ischemia.⁴ During the last 30 years, refinement of methods to identify patients at greatest risk for a perioperative cardiac event have evolved to the point that at least 2 widely used preoperative risk assessment models are available.^{5,6} The accuracy and predictive ability of these models is uncertain and, despite years of use, controversy exists about the ability of these risk models to predict outcomes.^{3,7-10} Because of this uncertainty, we used data from the Patient Safety in Surgery (PSS) Study, which was a collaboration between the Veterans Affairs (VA) National Surgical Quality Improvement Program (NSQIP) and the American College of Surgeons, to develop and test a risk model for CAE. We then developed and validated a risk index with the intention of providing a method to assess preoperative risk of CAEs in patients undergoing general and vascular operations.

METHODS

Detailed descriptions of the NSQIP and PSS Study methodologies have been reported previously and are summarized briefly here.¹¹⁻¹³ Patients from 128 VA medical centers and 14 private-sector hospitals participating in the PSS study from fiscal years 2002 through 2004, who underwent major general or vascular procedures, were assessed as part of this study.

Data collection

Each hospital had a risk-assessment nurse, who prospectively collected preoperative patient characteristics, including risk factors, intraoperative processes of care, and postoperative adverse occurrences up to 30 days after the operation on the first 36 (in the VA) or 40 (in the private sector) operations in each 8-day cycle. Entry of common

procedures, such as breast procedures and hernia repairs, were limited so that such patients would not overwhelm the database. Data, such as laboratory values, were pulled into the data set from other computerized sources within the VA and were either pulled from computerized systems or entered by the nurses in the private-sector hospitals. The nurses completed in-depth training on all study definitions. Regular conference calls, annual meetings, and site visits were used to maintain data reliability.

During the period of the study, the VA hospitals recorded a history of congestive heart failure as a cardiac preoperative risk factor. The private-sector hospitals recorded additional cardiac factors of history of angina, history of myocardial infarction, hypertension requiring medication, previous percutaneous transluminal coronary angioplasty, and previous cardiac operation. The private-sector hospitals also recorded height and weight, allowing for the calculation of body mass index and obesity class. The other 45 preoperative and intraoperative risk factors were recorded similarly in both VA and private-sector populations.

The index operation was defined as the first operation during the hospitalization for the patient, as some patients had more than one operation during their hospital stay. On the 30th postoperative day, the nurse obtained outcomes information through chart review, reports from morbidity and mortality conferences, and communication with each patient by letter or by telephone.

Multiple operations within 30 days were not counted in the totals. Data were collected on the postoperative occurrence of two types of CAEs: acute MI and cardiac arrest requiring cardiopulmonary resuscitation. Acute MI was defined as a new transmural acute myocardial infarction occurring during operation or within 30 days after operation, as manifested by new Q-waves on ECG. Non-Q-wave infarctions are not included in this definition. Cardiac arrest was defined as the absence of cardiac rhythm or presence of chaotic cardiac rhythm that results in loss of consciousness requiring the initiation of any component of basic or advanced, or both, cardiac life support. Patients who have automatic implantable cardioverter defibrillators that fire, but who have no loss of consciousness, are excluded from this definition. In our analysis, a patient with either of these two events was counted as having a CAE.

Statistical analysis

We used CAE as the dependent variable and used preoperative demographic and medical risk factors, preop-

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