EXPERT REVIEW

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Section Editor

Preoperative Cardiac Risk Assessment for Noncardiac Surgery: Defining Costs and Risks

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Cardiac risk stratification before noncardiac surgery remains important. Two major areas have been emphasized, namely, cost-effective risk stratification and enhanced identification of high-risk populations. Recent studies have highlighted the lack of quality and affordable medical consultation. The indications for resting preoperative echocardiography merit streamlining, given recent data that failed to demonstrate tangible benefit. Furthermore, noninvasive cardiac stress testing is expensive and unnecessary in low-risk patients. Perioperative troponin determination significantly improves the detection of myocardial infarction, facilitating its early management. The revised cardiac risk index is a standard tool for risk stratification, despite multiple limitations. The first approach has been to recalibrate the traditional risk index to specific high-risk surgical subgroups. The second approach has been to develop new cardiac risk models with more power. Both approaches have yielded risk calculators that outperform the traditional risk model. Furthermore, this latest generation of risk models is available as online calculators that can be accessed at the bedside. Further clinical trials are indicated to test the validity, clinical utility, and cost-effectiveness of these novel risk calculators. It is likely that these powerful instruments will refine the indications for specialized cardiac testing, offering multiple opportunities to reduce perioperative risk and cost simultaneously.

KEY WORDS: noncardiac surgery, medical consultation, echocardiography, anesthesia consultation, cardiac stress testing, costs, benefits, outcomes, cardiac risk, myocardial infarction, risk models, revised cardiac risk index, troponin, National Surgical Quality Improvement Program, lung resection, vascular surgery, vascular surgical group of New England, risk calculator

CARDIAC RISK STRATIFICATION before noncardiac surgery remains an ongoing priority because cardiac complications constitute a common cause of postoperative morbidity and mortality.[1-3] The literature highlights in this area have focused on 2 major clinical areas: the cost effectiveness of current risk stratification approaches and the further identification of high risk populations beyond the revised cardiac risk index.[4]

Recent studies have identified opportunities for improvement in the quality and affordability of medical consultation as part of perioperative risk stratification and management. The indications for resting preoperative echocardiography for risk assessment in noncardiac surgery merit further clarification, given recent data that failed to demonstrate improvements in outcome, costs, or quality. Furthermore, although noninvasive cardiac stress testing is indicated in high risk surgical cohorts, it appears to be expensive and unnecessary in low risk patients. Perioperative measurement of troponin in high risk patients undergoing noncardiac surgery significantly improves the detection of myocardial ischemia and infarction, thus offering major opportunities for aggressive early intervention for this serious perioperative complication. The cost effectiveness of this approach requires further study.

The revised cardiac risk index has become the preferred standard tool for risk stratification in noncardiac surgery, despite its limitations, such as a relatively small total sample size, inadequate representation of high risk subgroups, and failure to reflect recent innovations and improvements in perioperative care. To address these limitations, investigators have developed 2 approaches. The first approach has been to recalibrate the traditional risk index to specific high risk surgical subgroups such as patients undergoing lung resection or vascular surgery. The second approach has been to develop new cardiac risk models based on analyses of large contemporary surgical cohorts at least 100 times larger than the derivation cohort utilized for the revised cardiac risk index. Both approaches have yielded multiple risk calculators that outperform the traditional risk model. Furthermore, many of this latest generation of risk models are available as online calculators that can be accessed at the bedside. Further clinical trials are indicated to test the validity, clinical utility, and cost effectiveness of these novel

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perioperative risk calculators. It is likely that these powerful risk calculators can further refine the indications for specialized cardiac testing, offering multiple opportunities to reduce peri operative risk and cost simultaneously.

COST EFFECTIVENESS OF CURRENT RISK STRATIFICATION APPROACHES

Medical Consultation

Medical consultation may be indicated in the preoperative evaluation, although cost and the risk/benefit ratio should be considered.[5] The suboptimal effect of medical consultation on perioperative care for major noncardiac surgery was high lighted in a single center observational study (n 1,282, with a 9.1% consultation exposure rate between the years 2004 and 2006).[6] After adjusting for illness severity, perioperative medical consultation has no significant effect on glycemic control, beta blocker exposure, or prophylaxis for venous thromboembolism.[6] Furthermore, exposure to medical consul tation significantly increased hospital costs (24.4% higher; 95% confidence interval 13.5% 36.3%) and length of stay (13.0% longer; 95% confidence interval 1.6% 25.6%).[6] The investigators concluded that perioperative medical consultation did not improve efficiency or quality of care in surgical patients.[6]

The lack of effect of medical consultation was explored in a population based fashion for major elective adult noncardiac surgery in Ontario, Canada (n 269,866 with a 38.8% exposure to medical consultation between the years 1994 and 2004).[7] After adjusting with propensity scores, internist con sultation significantly increased preoperative testing, preopera tive pharmacologic interventions, mean hospital stay (0.67 days; 95% confidence interval 0.59 0.76), 30 day mortality (relative risk 1.16; 95% confidence interval 1.07 1.25; number needed to harm 516), and 1 year mortality (relative risk 1.08; 95% confidence interval 1.04 1.12; number needed to harm 227).[7] Furthermore, consultation had no effect on postoperative wound infections (relative risk 0.98; 95% confidence interval 0.05 1.02).[7] The investigators concluded that further research is essential to improve the outcome and cost benefits of medical consultation.

In a subsequent study (n 204,819 with a 38% medical consultation rate across 79 hospitals throughout Ontario between the years 1994 and 2004), the same investigators explored the variation in the conduct of preoperative medical consultation.[8] The consultation rate varied significantly across hospitals: the range was 10 to 897 consultations per 1,000 surgical procedures.[8] This extreme variation was not explained by procedure volume, hospital teaching status, or patient factors. The individual hospital was the main determinant of likelihood for medical consultation a local culture that appears to have a weak link to optimal patient outcomes and cost effectiveness.[7-8]

A possible solution to these identified concerns about perioperative medical consultation is to increase the utilization of anesthesia consultation.[9-10] The Ontario investigators again demonstrated that anesthesia consultation increased from 19% in 1994 to 53% in 2003 (n = 271,082 throughout Ontario between the years 1994 and 2004).[9] After propensity scoring, matched pair analysis demonstrated that anesthesia consultation reduced mean hospital stay (8.2 *v* 8.5 days; mean difference 0.3; 95% confidence interval 0.27 0.43; $p < 0.001$) but had no effect on 30 day mortality (relative risk 1.04; 95% confidence interval 0.96 1.13; p 0.36) or 1 year mortality (relative risk 0.98; 95% confidence interval 0.95 1.02; p 0.20).[9] The investigators recommended further trials to investigate the cost effectiveness of widespread anesthesia consultation in prepara tion for major noncardiac surgery. This paradigm may best be delivered by means of a specialized preanesthesia clinic.[10]

Resting Echocardiography

Transthoracic echocardiography is not uncommonly ordered as part of a preoperative evaluation for adult elective major noncardiac surgery.[7-9] In a recent large propensity corrected analysis (n = 264,823 adults throughout Ontario with a 15.1% exposure to resting echocardiography between the years 1999 and 2008), exposure to echocardiography within 6 months before surgery was associated with an increase in mean hospital stay (mean difference 0.31 days; 95% confidence interval 0.17 0.44 days; $p < 0.001$).[11] Furthermore, resting echocardiogra phy in this setting was significantly associated with increased mortality at 30 days (relative risk 1.14; 95% confidence interval 1.02 1.27; p 0.02; number needed to harm 423) and at 1 year (relative risk 1.07; 95% confidence interval 1.01 1.12; p 0.02; number needed to harm 222).[11] The data from this pivotal trial emphasize the call for further trials to define the perioperative indications for special tests such as resting echocardiography.[12]

Noninvasive Cardiac Stress Testing

Current guidelines have recommended noninvasive car diac stress testing in adults with clinical risk factors for perioperative cardiac complications, based on the revised cardiac risk index.[2-4] A survey of acute care hospitals throughout Ontario (n = 271,082 with an 8.9% exposure to noninvasive cardiac stress testing between the years 1994 and 2004) demonstrated that stress testing reduced mean hospital stay (mean difference 0.24; 95% confidence interval 0.07 0.43; $p < 0.001$) and improved 1 year survival (hazard ratio 0.92; 95% confidence interval 0.86 0.99; p = 0.03).[13] When these data were stratified by the revised cardiac risk index, stress testing was associated with harm in low risk patients (hazard ratio 1.35; 95% confidence interval 1.05 1.74) but with benefit in intermediate risk patients (hazard ratio 0.92; 95% confidence interval 0.85 0.99) and high risk patients (hazard ratio 0.80; 95% confidence interval 0.67 0.97).[13] These data are consistent with the current guidelines that recommend stress testing in patients with significant cardiac risk factors.[14] Furthermore, they point to a significant cost saving opportunity, namely, the elimination of expensive and unnecessary stress testing in low risk patients. If value in perioperative medicine is defined as outcome benefits per unit cost, then stress testing in low risk patients represents poor value.[15] It is becoming increasingly important for anesthe siologists to be good stewards of limited perioperative resources eliminating wasteful perioperative special testing