Systematic review: prediction of perioperative cardiac complications and mortality by the revised cardiac risk index

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CRD summary
This review concluded that the Revised Cardiac Risk Index discriminated moderately well between patients at low risk versus high risk for cardiac events after mixed noncardiac surgery and was less accurate in predicting death or major cardiac events after vascular noncardiac surgery. A degree of caution might be required in interpreting these conclusions given the limited quality of included studies.

Authors' objectives
To assess the ability of the Revised Cardiac Risk Index to predict cardiac complications and death after noncardiac surgery.

Searching
MEDLINE, EMBASE and ISI Web of Science were searched from inception to December 2008 without language restriction. Search terms were reported. Reference lists of included studies were screened.

Study selection
Randomised controlled trials (RCTs) or cohort studies that measured the predictive ability of the Revised Cardiac Risk Index for major cardiac complications (cardiac death, myocardial infarction and nonfatal cardiac arrest) or all-cause mortality in the hospital or within 30 days after surgery were eligible for inclusion. Eligible studies had to report either an area under the receiver-operating characteristic curve (AUC) for predicting the outcome or the number of outcome events in three or more categories of the Revised Cardiac Risk Index.

The patients’ demographic characteristics and comorbid conditions varied between studies. The percentage of patients in included studies who underwent high-risk surgery (defined as suprainguinal vascular, intrathoracic or intra-abdominal noncardiac surgery) ranged from 0% to 100%. Where reported, mean age of included patients varied from 47 to 77 years and the proportion of female patients was 0.9% to 59.1%.

Two reviewers independently assessed studies for inclusion. Any disagreements were resolved by consensus or a third reviewer.

Assessment of study quality
The quality of studies was assessed on the basis of the Standards for Reporting of Diagnostic Accuracy statement. The authors focused mainly on the following criteria: timing of data collection; selection criteria for participants; uniform surveillance for outcomes; and blinded assessment of outcomes. A high-quality study was defined as a prospective study with uniform outcome surveillance and blinded outcome assessment.

Two reviewers independently performed the validity assessment. Any disagreements were resolved by consensus or a third reviewer.

Data extraction
The data were extracted on the AUC for predicting the outcome or the number of outcomes of interest in three or more categories of the Revised Cardiac Risk Index. Study authors were contacted for unpublished data.

Two reviewers independently performed the data extraction. Any disagreements were resolved by consensus or a third reviewer.
Methods of synthesis
The studies were combined in meta-analyses. Pooled AUC with 95% confidence intervals (CIs) were calculated. The magnitude of a pooled AUC was defined as follows: low accuracy (<0.7); moderate accuracy (0.7 to 0.9) and high accuracy (>0.9). Statistical heterogeneity was assessed using the $I^2$ statistic. A random-effects model was used if $I^2$ was 50% or less, otherwise no pooling of study results was employed. Sensitivity analysis was performed by excluding the original validation study. If $I^2$ was more than 50%, random-effects metaregression was used to identify more homogenous subgroups.

A hierarchical summary receiver-operating characteristic (ROC) curve was derived to assess the predictive accuracy of the Revised Cardiac Risk Index; patients were classified as low-risk (0 to 1 point) versus intermediate to high-risk (≥2 points). Pooled measures of diagnostic test accuracy (sensitivity, specificity, positive and negative likelihood ratio) were calculated from the summary ROC curve.

Results of the review
Twenty-four studies (23 cohort studies and one RCT) were included in the review (n=792,740), half of which were prospective. Sample size varied from 44 to 663,635. Methodological quality varied between studies. Twelve studies used systematic surveillance for cardiac complications. Nine studies used blinded outcome assessment. Only six studies were judged as high quality. The follow-up duration ranged from three to 30 days.

Perioperative cardiac complications (18 studies; n=124,032):

The Revised Cardiac Risk Index discriminated moderately well between patients at low risk versus high risk for cardiac events after mixed noncardiac surgery (pooled AUC 0.75, 95% CI 0.72 to 0.79; 10 studies). A moderate statistical heterogeneity ($I^2=48\%$) was observed in the pooled outcome. When evaluating the predictive accuracy of the Revised Cardiac Risk Index for classifying patients as low-risk versus intermediate to high-risk, it had a sensitivity of 0.65 (95% CI 0.46 to 0.81), a specificity of 0.76 (95% CI 0.58 to 0.88), a positive likelihood ratio of 2.78 (95% CI 1.74 to 4.45) and a negative likelihood ratio of 0.45 (95% CI 0.31 to 0.67).

The Revised Cardiac Risk Index was less accurate in predicting cardiac events after vascular noncardiac surgery (pooled AUC 0.64, 95% CI 0.61 to 0.68; seven studies). A moderate statistical heterogeneity ($I^2=29\%$) was observed in the pooled outcome. When evaluating the predictive accuracy of the Revised Cardiac Risk Index for classifying patients as low-risk versus intermediate to high-risk, it had a sensitivity of 0.70 (95% CI 0.53 to 0.82), a specificity of 0.55 (95% CI 0.45 to 0.66), a positive likelihood ratio of 1.56 (95% CI 1.42 to 1.73) and a negative likelihood ratio of 0.55 (95% CI 0.40 to 0.76).

Sensitivity analyses did not materially affect the results. The authors reported that pooling of AUCs from the total 18 studies was not performed due to high statistical heterogeneity ($I^2=82\%$). The random-effects metagression showed that only the variable of surgery type (vascular noncardiac versus mixed noncardiac) significantly accounted for this heterogeneity (p=0.01).

Perioperative all-cause mortality (six studies, n=668,708):

The Revised Cardiac Risk Index was less accurate in predicting all-cause mortality (median AUC of 0.62, range from 0.54 to 0.78). A pooled AUC was not performed due to high statistical heterogeneity ($I^2=95\%$).

Authors' conclusions
The Revised Cardiac Risk Index demonstrated moderate performance in discriminating between patients at low risk versus high risk for cardiac events after mixed noncardiac surgery; it was less accurate in predicting death or major cardiac events after vascular noncardiac surgery.

CRD commentary
This review's inclusion criteria were clear. Several relevant databases were searched. Efforts were made to find published and unpublished studies without language restriction, thereby minimising the possibility of publication and language biases. Sufficient attempts have been taken to minimise the errors and biases in the review process. Relevant
criteria were used to examine the study quality. Statistical heterogeneity was assessed and appropriate methods were used to pool the results. This review was generally well conducted and the authors’ conclusions reflected the evidence presented. As the authors acknowledged, a degree of caution might be required in interpreting these conclusions in light of the low methodological quality of most of the included studies.

**Implications of the review for practice and research**

**Practice:** The authors stated that it is reasonable for clinicians to use the Revised Cardiac Risk Index to discriminate between patients at low risk versus high risk for perioperative cardiac complications after mixed noncardiac surgery.

**Research:** The authors stated that high-quality studies were required to evaluate the Revised Cardiac Risk Index for predicting perioperative cardiac risk. Future studies should also investigate whether an alternative index of combining the ease of use of the Revised Cardiac Risk Index with improved predictive accuracy can be developed. Future studies should not use the AUC alone to measure the predictive performance of these indices. Future studies should use more consistent definitions of perioperative cardiac complications and measure a broad range of performance measures (such as calibration and risk stratification capacity) of the indices.

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