

Clinical Decision Tool Reviews

Updated Review of Revised Cardiac Risk Index

Jeffrey Chan, MBChB, MPH, FESC

Keywords: Revised Cardiac Risk Index for Pre-Operative Risk, cardiac risk, cardiac risk index, cardiac risk calc, cardiac risk after surgery, cardiac risk prior to surgery, cardiac risk s/p surgery, cardiac risk online, cardiac risk non cardiac surgery, cardiac risk non-cardiac surgery, surgery cardiac risk, revised cardiac risk, revised cardiac calc, revised cardiac disease calc, lee index, mace

Evidence to Action: Official Journal of MDCalc

Vol. 042025, Issue 01, 2025

Article Information

Keywords: Revised Cardiac Risk Index for Pre-Operative Risk, cardiac risk, cardiac risk index, cardiac risk calc, cardiac risk after surgery, cardiac risk prior to surgery, cardiac risk s/p surgery, cardiac risk online, cardiac risk non cardiac surgery, cardiac risk non-cardiac surgery, surgery cardiac risk, revised cardiac risk, revised cardiac calc, revised cardiac disease calc, lee index, mace

<https://doi.org/10.65357/001c.154409>

Submitted: September 16, 2025 EST

Accepted: October 15, 2025 EST

Published: October 16, 2025 EST

Abstract

This calculator estimates the risk of cardiac complications after noncardiac surgery.

I. HOW TO USE

When to Use

- Patients ≥ 45 years old (or 18-44 years old with significant cardiovascular disease) undergoing elective non-cardiac surgery or urgent/semi-urgent (non-emergent) non-cardiac surgery.
- Use with caution in patients undergoing emergency surgery or vascular surgery, as the score is not as well validated for the former, and performance is known to be poor for the latter.

Pearls / Pitfalls

- Easy to use by any involved specialty, including general internal medicine, cardiology, anesthesia, and surgery.
- Can be used in the inpatient or outpatient preoperative setting.
- Includes a limited number of risk factors, in part because the original studies did not include a sufficient number of patients for every important risk

factor (e.g. underestimates hemodynamic and cardiovascular outcomes in valvular disease).

- Other patient important outcomes that are *not* assessed by this tool include risk of stroke, major bleeding, prolonged hospitalization, and ICU admission.

While the [2017 Canadian Cardiovascular Society](#) specified RCRI in their preoperative cardiovascular assessment algorithm for patients undergoing elective surgery, more recent [European \(2022\)](#) and [American \(2024\)](#) guidelines no longer recommend any specific tool,

Why Use

- Provides individualized risk stratification prior to undergoing surgery, which can be helpful in discussions of informed consent.
- RCRI contains 6 objective, binary variables and is scored in an additive manner.
- In patients with elevated risk (RCRI ≥ 1 , age ≥ 65 , or age 45-64 with significant cardiovascular disease), helps direct further preoperative risk stratification (e.g. with serum NT-proBNP or BNP) and

determine appropriate cardiac monitoring post-op (EKG, troponins).

II. NEXT STEPS

Advice

According to the [2017 CCS Perioperative Guidelines](#):

- If the RCRI is ≥ 1 , the patient's age is ≥ 65 , or they are between 45-64 with significant cardiac disease, consider obtaining NT-ProBNP or BNP.
- If the NT-ProBNP is ≥ 300 ng/L or BNP is ≥ 92 ng/L, an EKG should be ordered in the PACU and troponins should be measured daily for 48-72 hours.
- If, after risk stratification, the NT-ProBNP is <300 ng/L or BNP <92 ng/L, no routine postoperative cardiac monitoring is warranted.
- If the institution does not have these assays available, then all patients should be monitored with an EKG in the PACU and troponin measurements daily for 48-72 hours if they meet one of the following: RCRI ≥ 1 , age ≥ 65 , or age 45-64 with any of the following: known history of coronary artery disease, cerebral vascular disease, peripheral artery disease, congestive heart failure, severe PHTN, or a severe obstructive intracardiac abnormality (e.g. severe aortic stenosis, severe mitral stenosis, or severe hypertrophic obstructive cardiomyopathy).

The data supporting the use of NT-ProBNP/BNP comes from a large 2014 meta-analysis of 18 studies with a total of 2,477 patients ([Rodseth 2014](#)). This study, which was in agreement with multiple previous meta-analyses, noted that for those patients with a pre-operative NT-ProBNP of <300 ng/L or BNP <92 ng/L, the rate of 30-day postoperative non-fatal MI or death was 4.9% (3.9%-61%), and was 21.8% (19.0%-24.8%) in those with pre-operative NT-ProBNP is ≥ 300 ng/L or BNP is ≥ 92 ng/L.

III. EVIDENCE

Evidence Appraisal

The Revised Cardiac Risk Index (RCRI; also called the Lee index) is an update to the older, 9-item risk score by Goldman et al published in 1977. [Published in 1999](#), RCRI was a six-item risk score derived and validated for predicting myocardial infarction, pulmonary edema, ventricular fibrillation or primary cardiac arrest, and complete heart block in 4315 patients aged 50 or above who underwent nonemergent noncardiac procedures with an expected length of stay ≥ 2 days at Brigham and Women's Hospital between 1989 and 1994. The original study used the hold-out method, where two thirds of the patients (i.e. $n=2893$) were used for deriving the model, and

one-third (i.e. $n=1422$) was used for validating the model. Here, RCRI achieved an AUROC of 0.759 in the derivation cohort and 0.806 in the validation cohort.

Of note, the model was derived using a two-stage process using logistic regression, with the first stage involving univariable regression to screen for potential predictors, which are then included in the second stage which further selected significant predictors using step-wise logistic regression. Such approach has since been found to be of questionable reliability, and has been largely superseded by other variable selection methods such as LASSO and elastic net regression. Initially, generalizability of the model was limited for a variety of reasons. Death was not part of the outcome and the use of logistic regression implied that competing risk was not taken into consideration, which may have been partially mitigated by the short outcome duration. The derivation study also excluded patients expected to require <2 days of hospitalization and the authors observed that those who did not consent to the study had significantly higher rates of postoperative cardiac events (1.7% versus 4.8%; $P<0.001$).

Since the publication of the [original study](#) in 1999, a large number of validation studies have been performed. These were summarized in a systematic review by [Ford et al in 2010](#), which found that RCRI had moderate discrimination ability for cardiac events after mixed non-cardiac surgery (AUROC 0.75 [95% CI, 0.72 to 0.79]). However, an important caveat was that most studies included by this systematic review did not study the same outcome as the original study by Lee et al. In fact, of the 24 meta-analyzed studies, only 1 (aside from the original study) used the same outcomes. In studies that included death as part of the outcome, the AUROC values were substantially lower (0.62 [range, 0.54 to 0.78]). [A subsequent study by Cohn and Ros](#) confirmed that RCRI had good discriminatory ability for postoperative cardiovascular events as defined by the original study, but was not significantly predictive of 30-day mortality. A more contemporary study by [Roshanov et al](#) found the RCRI to have mediocre discriminatory ability, with an AUROC of 0.69 [95% CI: 0.65-0.72] only. This raises the possibility of issues with the model's temporal validity, i.e. whether over-time changes in care and patient characteristics have substantially impacted its performance.

Other studies have claimed that RCRI severely underestimated the risk of cardiac events. This was partly true, likely due to the increasing use of troponin measurements for diagnosing myocardial infarction since the publication of the original study. However, many such studies also looked at outcomes that differed substantially from what was used in the original study, which may have also contributed to apparent underestimation.

The omission of cardiac death meant that the outcome deviated significantly from the conventional definitions of major adverse cardiovascular event (MACE),

which has become a common endpoint for other similar risk scores. To this end, and to address concerns with calibration, the [2017 Canadian guidelines](#) have pooled estimates from several high-quality validation studies to update the estimated risk for each score level, with the outcome changed to include 30-day mortality. These estimates were also reported by the [2022 European guidelines](#).

However, it is worth noting that only one of these studies, the [VISION Pilot study](#), had the goal of prospectively validating the RCRI; all other studies ([Rajagopalan et al](#), [Ausset et al](#), and [Sheth et al](#)) did not aim to do so specifically but reported appropriate and poolable estimates. Another large international prospective study by [Roshanov et al](#), which was a secondary analysis of the VISION study, was published in 2021. It should be pointed out that the latest [2024 American guidelines](#) did not list the exact risk estimates for each score level, and instead referred to RCRI >1 as denoting elevated risk.

Lastly, it is worth mentioning that the RCRI is known to perform poorly in patients undergoing vascular surgery, possibly because the indications for such procedures typically carry a higher cardiac risk. In particular, [a 2019 study by Fronczek et al](#) using data from the VISION study showed that both RCRI and the NSQIP MICA risk score underestimated the risk of major cardiac events in patients undergoing vascular surgery, with both showing no clinical utility at all in decision curve analysis.

Formula

Addition of the selected points:

Risk Factor	Description	Points
High-risk surgery	Intraoperative; intrathoracic; suprainguinal vascular	+1
History of ischemic heart disease	History of myocardial infarction (MI); history of positive exercise test; current chest pain considered due to myocardial ischemia; use of nitrate therapy or ECG with pathological Q waves	+1
History of congestive heart failure	Pulmonary edema, bilateral rales or S3 gallop; paroxysmal nocturnal dyspnea; chest x-ray (CXR) showing pulmonary vascular redistribution	+1
History of cerebrovascular disease	Prior transient ischemic attack (TIA) or stroke	+1
Pre-operative treatment with insulin	--	+1
Pre-operative creatinine >2 mg/dL / 176.8 µmol/L	--	+1

Facts & Figures

Interpretation per the 2017 CCS guidelines and 2022 ESC guidelines:

RCRI Score	Risk of major cardiac event* [95% confidence interval]
0	3.9% [2.8%-5.4%]
1	6.0% [4.9%-7.4%]

2	10.1% [8.1%-12.6%]
≥3	15.0% [11.1%-20.0%]

*2024 American guidelines did not list the exact risk estimates for each score level, and instead referred to RCRI >1 as denoting elevated risk.

Interpretation per more contemporary estimates using data from VISION, an international prospective cohort study (from [Roshanov et al 2021](#)):

RCRI Score	Risk of major cardiac event* [95% confidence interval]
0	1.6%
1	4.0%
2	7.9%
≥3	12.9%

*Defined as myocardial infarction, cardiac arrest, or death at 30 days after noncardiac surgery

LITERATURE

Original/Primary

<https://www.ncbi.nlm.nih.gov/pubmed/10477528>

Lee TH, Marcantonio ER, Mangione CM, Thomas EJ, Polanczyk CA, Cook EF, Sugarbaker DJ, Donaldson MC, Poss R, Ho KK, Ludwig LE, Pedan A, Goldman L. Derivation and prospective validation of a simple index for prediction of cardiac risk of major noncardiac surgery. *Circulation*. 1999 Sep 7;100(10):1043-9. PubMed PMID: 10477528.

Validation

<http://www.ncbi.nlm.nih.gov/pubmed/20048269>

Ford MK, Beattie WS, Wijesundera DN. Systematic review: prediction of perioperative cardiac complications and mortality by the revised cardiac risk index. *Ann Intern Med*. 2010;152(1):26-35.

<https://pubmed.ncbi.nlm.nih.gov/31256916/>

Fronczek J, Polok K, Devereaux PJ, Górka J, Archbold RA, Biccari B, Ducepe E, Le Manach Y, Sessler DI, Duchińska M, Szczeklik W. External validation of the Revised Cardiac Risk Index and National Surgical Quality Improvement Program Myocardial Infarction and Cardiac Arrest calculator in noncardiac vascular surgery. *Br J Anaesth*. 2019 Oct;123(4):421-429. doi: 10.1016/j.bja.2019.05.029. Epub 2019 Jun 27. PMID: 31256916.

<https://pubmed.ncbi.nlm.nih.gov/33766613/>

Roshanov PS, Sessler DI, Chow CK, Garg AX, Walsh MW, Lam NN, Hildebrand AM, Biccari BM, Acedillo RR, MacNeil SD, Lee VW, Szczeklik W, Mrkobrada M, Thabane L, Devereaux PJ. Predicting Myocardial Injury and Other Cardiac Complications After Elective Noncardiac Surgery with the Revised Cardiac Risk Index: The VISION Study. *Can J Cardiol*. 2021 Aug;37(8):1215-1224. doi:

10.1016/j.cjca.2021.03.015. Epub 2021 Mar 23. PMID: 33766613.

<https://pubmed.ncbi.nlm.nih.gov/29126584/>

Cohn SL, Fernandez Ros N. Comparison of 4 Cardiac Risk Calculators in Predicting Postoperative Cardiac Complications After Noncardiac Operations. *Am J Cardiol.* 2018 Jan 1;121(1):125-130. doi: 10.1016/j.amjcard.2017.09.031. Epub 2017 Oct 13. PMID: 29126584.

<http://www.ncbi.nlm.nih.gov/pubmed/22567075>

VISION Pilot Study investigators, Devereaux PJ, Bradley D, Chan MT, et al. An international prospective cohort study evaluating major vascular complications among patients undergoing noncardiac surgery: the VISION Pilot Study. *Open Med.* 2011;5(4):e193-200.

<http://www.ncbi.nlm.nih.gov/pubmed/17666156>

Ausset S, Auroy Y, Lambert E, et al. Cardiac troponin I release after hip surgery correlates with poor long-term cardiac outcome. *Eur J Anaesthesiol.* 2008;25(2):158-64.

<http://www.ncbi.nlm.nih.gov/pubmed/25902738>

Sheth T, Chan M, Butler C, et al. Prognostic capabilities of coronary computed tomographic angiography before non-cardiac surgery: prospective cohort study. *BMJ.* 2015;350:h1907.

<https://pubmed.ncbi.nlm.nih.gov/23813289/>

Davis C, Tait G, Carroll J, Wijesundera DN, Beattie WS. The Revised Cardiac Risk Index in the new millennium: a single-centre prospective cohort re-evaluation of the original variables in 9,519 consecutive elective surgical patients. *Can J Anaesth.* 2013 Sep;60(9):855-63. doi: 10.1007/s12630-013-9988-5. Epub 2013 Jun 28. PMID: 23813289.

Guidelines

<https://pubmed.ncbi.nlm.nih.gov/39320289/>

Thompson A, Fleischmann KE, Smilowitz NR, et al. 2024 AHA/ACC/ACS/ASNC/HRS/SCA/SCCT/SCMR/SVM Guideline for Perioperative Cardiovascular Management for Noncardiac Surgery: A Report of the American College of Cardiology/American Heart Association Joint Committee on Clinical Practice Guidelines. *J Am Coll Cardiol.* 2024. <https://doi.org/10.1016/j.jacc.2024.06.013> [online ahead of print]

<https://pubmed.ncbi.nlm.nih.gov/36017553/>

Halvorsen S, Mehilli J, Cassese S, Hall TS, Abdelhamid M, Barbato E, De Hert S, de Laval I, Geisler T, Hinterbuchner L, Ibanez B, Lenarczyk R, Mansmann UR, McGreavy P, Mueller C, Muneretto C, Niessner A, Potpara TS, Ristić A, Sade LE, Schirmer H, Schüpke S, Sillesen H, Skulstad H, Torracca L, Tutarel O, Van Der Meer P, Wojakowski W, Zacharowski K; ESC Scientific Document Group. 2022 ESC Guidelines on cardiovascular assessment and management of patients undergoing non-cardiac surgery. *Eur Heart J.* 2022 Oct 14;43(39):3826-3924. doi: 10.1093/eurheartj/ehac270. Erratum in: *Eur Heart J.* 2023 Nov 7;44(42):4421. doi: 10.1093/eurheartj/ehad577. PMID: 36017553.

<http://www.ncbi.nlm.nih.gov/pubmed/27865641>

Duceppe E, Parlow J, Macdonald P, et al. Canadian Cardiovascular Society Guidelines on Perioperative Cardiac Risk Assessment and Management for Patients Who Undergo Noncardiac Surgery. *Can J Cardiol.* 2017;33(1):17-32.

Other References

<https://www.ncbi.nlm.nih.gov/pubmed/904659>

Goldman L, Caldera DL, Nussbaum SR, Southwick FS, Krogstad D, Murray B, Burke DS, O'Malley TA, Goroll AH, Caplan CH, Nolan J, Carabello B, Slater EE. Multifactorial index of cardiac risk in noncardiac surgical procedures. *N Engl J Med.* 1977 Oct 20;297(16):845-50. PubMed PMID: 904659.

<http://www.ncbi.nlm.nih.gov/pubmed/18586440>

Rajagopalan S, Croal BL, Bachoo P, Hillis GS, Cuthbertson BH, Brittenden J. N-terminal pro B-type natriuretic peptide is an independent predictor of postoperative myocardial injury in patients undergoing major vascular surgery. *J Vasc Surg.* 2008;48(4):912-7.

<http://www.ncbi.nlm.nih.gov/pubmed/24076282>

Rodseth RN, Biccari BM, Le Manach Y, et al. The prognostic value of pre-operative and post-operative B-type natriuretic peptides in patients undergoing noncardiac surgery: B-type natriuretic peptide and N-terminal fragment of pro-B-type natriuretic peptide: a systematic review and individual patient data meta-analysis. *J Am Coll Cardiol.* 2014;63(2):170-80.