Original article

A look into Lee's score: peri-operative cardiovascular risk assessment in non-cardiac surgeries—usefulness of revised cardiac risk index

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KEY WORDS

Non-cardiac surgeries
Peri-operative evaluation
Revised cardiac risk index

ABSTRACT

Objective: The revised cardiac risk index (RCRI/Lee's score) was designed for peri-operative risk assessment before elective major non-cardiac surgeries. Through this article, we report the usefulness of RCRI in our daily practice, while evaluating patients undergoing surgeries of varying risk.**Methods:** Only referred patients, aged ≥ 40 years, were included. Risk stratification was done using RCRI scoring system. Patients were categorised into 4 classes depending on 0, 1, 2, and ≥ 3 risk predictors (risk predictors were high-risk surgery, history of ischaemic heart disease (IHD), diabetes on insulin, history of stroke (cerebrovascular accident [CVA]), history of congestive heart failure (CHF) and serum creatinine of >2 mg%). Electrocardiograms (ECG) were done in all patients, while troponin I in intermediate and high-risk patients, and in others if symptomatic. Peri-operative cardiovascular events were managed appropriately.**Results:** Of the 920 patients included, only 853 patients were analysed as 67 patients were not operated upon. The mean age was 59 ± 11 years and 46% of the patients were women. Two hundred and ninety-two underwent high-risk surgeries, 97 patients had history of IHD, 89 had history of CHF, 36 gave history of CVA, 269 patients were diabetics on insulin and 68 had serum creatinine >2 mg%. Number of patients in Lee's classes I, II, III, and IV were 311, 347, 150, and 52, respectively. 26 out of 853 patients had peri-operative events. Of the six variables in RCRI, only history of IHD was an independent predictor of events. Event rates increased as the RCRI class increased, i.e. 1.7%, 2.0%, 6.7%, and 7.7% for classes I–IV, respectively. Age >70 years, poor general medical condition, emergency surgery and left bundle branch block (LBBB) on ECG, were significantly associated with peri-operative events.**Conclusion:** The RCRI is a useful tool in pre-operative risk stratification. It should perhaps be further updated to improve its predictive accuracy.

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Introduction

The peri-operative period provides a physician with a golden opportunity to assess the cardiac status of patients undergoing surgery. Many patients with risk factors undergoing non-cardiac surgery could have underlying silent coronary heart disease. As cardiovascular complications are an important cause of morbidity and mortality with major non-cardiac procedures, it is imperative that patients need to be evaluated

and peri-operative coronary risk be reduced. Many scoring systems are described in literature. Goldman's pioneering work in 1977 led to a methodical assessment of peri-operative cardiac risk.¹ Workup for cardiac disease is most helpful in patients at intermediate risk of the peri-operative events. No pre-operative cardiovascular testing should be performed if the results do not change peri-operative management and outcome.

Revised cardiac risk index² by Lee et al. (RCRI/Lee's score) was proposed in 1999, and comprises six independent risk factors. These six factors are high-risk type of surgery, history of ischaemic heart disease (IHD), history of congestive heart failure (CHF),

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history of cerebrovascular disease, pre-operative treatment with insulin, and pre-operative serum creatinine >2.0 mg/dL. In their study, the rates of major cardiac complication with 0, 1, 2, or ≤ 3 of these factors were 0.4%, 0.9%, 7%, and 11%, respectively. Through this study, we aimed to assess the utility of RCRI in peri-operative risk assessment of patients undergoing non-cardiac surgeries of varying risk, as in daily practice.

Methods

All patients over 40 years of age, referred to the Cardiology Department for pre-operative risk stratification, were included in the study during the period 2006–2007. The study population included 920 patients who were risk stratified for various surgeries. Sixty-seven patients were not operated upon, hence, only 853 patients were considered for the analysis (Figure 1).

Pre-operative evaluation included a detailed medical history including risk factors, prior cardiovascular disease, other major systemic diseases and treatment history. Objective assessment included an electrocardiogram (ECG), echocardiogram, and exercise stress test when feasible. Risk stratification was done using Lee's scoring system, and patients were categorised into four classes, namely I, II, III, and IV depending on the presence of 0, 1, 2, and ≥ 3 risk predictors, respectively. All patients had ECGs done pre-operatively, immediate post-operative, and on day 1 after surgery. Troponin I was estimated in intermediate and high-risk patients, and in others if symptomatic.

Statistical methods

Descriptive statistical analysis was carried out in the present study. Results on continuous measurements are presented as mean $\pm$ SD (min–max) and results on categorical measurements are presented as number (%). Significance was assessed at 5% level of significance. Student *t*-test (two tailed, independent) was used to find the significance of study parameters on continuous scale between the 2 groups. Inter

group analysis χ^2 /Fisher exact test was used to determine the significance of the study parameters on the categorical scale between the 2 groups. Receiving operating curve (ROC) analysis was performed to find the diagnostic performance of Lee's score. Statistical software, namely SPSS 15.0 was used for the analysis.

Results

The baseline characteristics are outlined in Table 1.

The mean age of the patients was 59.9 ± 11 years and 46% were women. Two hundred and ninety-two patients (34.2%) underwent high-risk surgeries, 97 (11.7%) had history of IHD, 89 (10.4%) had history of CHF, 36 (4.2%) gave history of cerebrovascular accident (CVA), 269 (31%) were diabetics on insulin, and 68 patients (8%) had serum creatinine >2 mg%.

The number of patients in Lee's classes I, II, III, and IV were 304 (36%), 347 (41%), 150 (17%) and 52 (6%), respectively (Figure 1). The various surgeries done are listed in Table 2.

Table 1

Baseline characteristics and association with cardiovascular events.

Variable	Events <i>n</i> =26 (%)	Non-events <i>n</i> =827 (%)	<i>P</i> value
Age ($\pm$ SD)	64.5 (10.6)	59.9 (11.7)	0.048
Age >70 (yr)	10 (38.5)	157 (18.3)	0.01
Sex			0.436
Male	16 (61.5)	445 (53.8)	
Female	10 (38.5)	382 (46.2)	
Hypertension	19 (73.1)	504 (60.9)	0.221
DM on insulin	11 (42.3)	258 (31.2)	0.230
Myocardial infarction	7 (26.9)	62 (7.5)	<0.001
Acute pulmonary oedema	2 (7.7)	19 (2.3)	0.132
CVA	0	36 (4.4)	–
CHF	1 (3.8)	19 (2.3)	1
Creatinine >2	4 (15.4)	64 (9.7)	0.501
Emergency	7 (26.9)	33 (4)	<0.001
Poor effort tolerance	5 (19.2)	81 (9.8)	0.172
Poor general medical status	5 (19.3)	13 (1.6)	0.001
Pathological Q waves	6 (23.1)	64 (7.7)	0.015

CHF: congestive heart failure, CVA: cerebrovascular accident, DM: diabetes mellitus, SD: standard deviation.

Table 2

Categories of cases.

Types of surgeries	Numbers (%)
High-risk surgeries	292 (34.2)
Orthopaedic	188 (22)
Head and neck	63 (7.4)
Other vascular	13 (1.5)
Spine	52 (6)
Others	136 (16)
Minor	46 (5.4)
Endoscopic	63 (7.4)

Figure 1 Material, patient class, and event rates.

End points

Twenty-six (~3%) patients suffered from a peri-operative event. The events were as shown in Figure 2. Non-ST-elevation myocardial infarction (NSTEMI) was the most common type of acute coronary syndrome followed by unstable angina. One patient developed ST-elevation myocardial infarction (STEMI) and succumbed to refractory arrhythmia. Two patients had acute pulmonary oedema, 1 each due to pre-existing LV dysfunction and NSTEMI. There were three deaths in total, one due to STEMI and the other two were sudden cardiac deaths in a patient suffering from hypertrophic obstructive cardiomyopathy (HOCM) on dual chamber pacemaker and the other a case of triple vessel disease.

Figure 2 Types of events. NSTEMI: non-ST-elevation myocardial infarction, STEMI: ST-elevation myocardial infarction.

Table 3

Rates of major cardiac complications and multivariate ORs* among patients with individual risk factors.

Revised cardiac risk index variables	Events/pop (%)	OR	Adj OR	95% CI	P value
HRS ^a	10/292 (3.4)	1.08	–	0.43, 2.3	0.92
IHD ^b	10/97 (10.3)	5.32	4.98	2.04, 12.16	<0.001
CHF ^c	4/89 (4.5)	1.58	1.09	0.13, 9.52	0.94
CVA	0/36 (0)	–	–	–	–
Pre-operative insulin therapy	11/269 (4)	1.62	1.07	0.44, 2.57	0.88
Serum creatinine >2mg%	4/68 (5.8)	1.7	1.26	0.39, 4.11	0.69

*Based on logistic regression models including these six variables.

^aIntraperitoneal, intrathoracic and suprainguinal vascular surgeries.

^bHistory of angina, history of myocardial infarction not revascularised, TMT positive for inducible ischemia, pathological Q waves.

^cHistory of CHF, CXR evidence of pulmonary venous hypertension, LV S3, rales suggestive of pulmonary oedema.

CHF: congestive heart failure, CI: confidence interval, CVA: cerebrovascular accident, CXR: chest X-ray, HRS: high-risk surgery, IHD: ischaemic heart disease, OR: odds ratio, TMT: trial making test.

Table 4

Major cardiac complication rates and 95% confidence interval in the study cohorts stratified by Lee's class.

Lee's class	Event group	Non-event group	OR	95% CI	P value
I	5 (19.2)	299 (36)	1	–	–
II	7 (26.9)	340 (41.3)	1.22	0.38–3.88	0.74
III	10 (38.5)	140 (17)	4.23	1.42–12.6	0.01
IV	4 (15.4)	48 (5.8)	4.93	1.28–19.02	0.02

CI: confidence interval, OR: odds ratio.

On univariate analysis, age >70 years, history of IHD, history of MI, pathological Q waves, left bundle branch block (LBBB) on ECG, poor general medical condition (defined by hypoxia, hypercarbia, hypokalaemia, renal failure, bedridden state) and emergency surgeries, all correlated independently with peri-operative events (*P* values 0.01, <0.001, 0.015, 0.005, 0.001, <0.001, respectively). Unstable angina within the past 6 months tended to be associated with higher peri-operative event rate (*P*=0.059).

Only one among the 6 factors of RCRI was an independent correlate of peri-operative cardiac event, i.e. IHD (Adj OR 4.98 95% CI [2.04–12.16], *P*<0.001) (Table 3).

The event rates in classes III and IV were significantly higher than class II (6.7% and 7.7% vs 2%, *P*=0.009, and 0.04, respectively). The difference between class IV and class III in event rates was not very different (7.7% vs 6.7%, *P*=0.759) (Table 4).

Event rates increased as the RCRI class increased, 1.6%, 2.0%, 6.7%, and 7.7% for classes I–IV, respectively (Figure 1). Area under the ROC curve for RCRI was 0.65.

Performance by procedure type

Analysis of the performance of the RCRI within types of procedures showed that only peripheral vascular surgeries showed trend towards higher cardiac complication rates (OR 4.58, *P*=0.090).

Protective effects of drugs on outcomes were not obvious (Table 5).

Table 5

Impact of drugs in patients who were already on them.

Drug	Total number of patients taking the drug	Patients taking drugs in the event group	P value
Aspirin	126/842	9/26	0.09
Beta-blockers	191/840	8/24	0.10
ACEI	116/841	9/23	0.10
Statins	124/841	4/23	0.16

ACEI: angiotensin-converting enzyme inhibitor.

Discussion

Only patients undergoing elective, major non-cardiac surgeries were studied by Lee et al. We considered patients undergoing various non-cardiac surgeries of differing surgical risks, and both elective and emergency procedures. This we believe is more real world. The presence of 2 or more of the 6 risk predictors in the RCRI is associated with high complication rates like in the original study. This is also in line with various studies which indicate that risk of surgery increases as the number of co-morbidities increase.

The event rate in our study was 3% which is much higher than the reported 1%.³ This could be due to the fact that we considered unstable angina and NSTEMI also as peri-operative events and not just MI, which was considered as a major cardiac complication in Lee's study. Additionally we also measured troponin I in all intermediate and high-risk patients, unlike creatinine kinase-MB which was relied upon for a diagnosis of MI in the original study. This explained the higher event rate in view of the increased sensitivity of troponin.

Certain conditions like diabetes mellitus, impaired renal function, and prior strokes are known to be associated with higher peri-operative cardiovascular events. But, these factors were not independently predictive of coronary events in our study.

A third heart sound or signs of heart failure portend worse cardiac outcomes after major surgeries.^{1,4} Again, heart failure was not an independent predictor in our study. Conflicting evidence exists regarding the risk in patients with hypertrophic cardiomyopathy. A retrospective study had shown higher peri-operative events in these patients.⁵ We had 4 patients with HCM (two were obstructive), and one of them (HOCM) had a sudden cardiac death following hip replacement under spinal anaesthesia. General anaesthesia may be better in these patients.

Advanced age is found to be a significant predictor of cardiac events.⁶ In our study too, we found the mean age in the event group to be significantly higher than the non-event group, and age >70 years was a significant risk factor for peri-operative complications. Severe aortic stenosis is classified as an active cardiac condition in the American College of Cardiology (ACC)/American Heart Association (AHA) guidelines,⁷ while some studies have not shown severe AS to be a risk predictor.^{8–10} We had only 2 patients with severe aortic stenosis but none had an event. Left bundle branch block is associated with higher peri-operative events.¹¹ Of the 12 patients with LBBB, 3 (25%) developed an event ($P=0.005$). Traditionally, cardiac risk stratification and further testing is advised for patients undergoing intermediate and high-risk surgeries as they benefit most, which does not make low-risk surgeries cardiac risk free. We found that even patients undergoing low-risk procedures can develop peri-operative cardiac event if their risk level is high. In our study, four of the 26 patients who had an event, underwent low-risk surgeries, but were classified as intermediate and high-risk by RCRI. There was a tendency towards significant association between cardiac complications and peripheral vascular surgery.

Hypertensive patients are at twice the risk of developing postoperative myocardial ischaemia and higher risk of peri-operative death.^{12,13} Hypertension if <180/110 mmHg is not found to be associated with cardiac complications.¹³ Blood pressure was well controlled pre-operatively in our patients and was not a predictor of CV events.

Bodenheimer,¹⁴ suggested improved outcomes are more likely to result from controlling postoperative oxygen demand than additional risk stratification. Beta-blockers were not protective in those patients with new wall motion abnormalities in greater than five segments on dobutamine stress echo.¹⁵ This group with risk factors and extensive wall motion abnormalities on pre-operative stress echo may be the group to consider for prophylactic coronary revascularisation. We did not do dobutamine stress echo in our study. We found no significant protection provided by beta-blockers. The possible explanations could be many. First, our cases did not include many very high-risk cases in which this class of drug is proven to benefit.^{16–18} Second, the average heart rate (81 bpm) between those who were and those who were not on beta-blockers was no different. Third, the duration of beta-blockade before surgery was short in a significant number of patients and evidence points to the probable benefit in patients who are on these drugs for longer period of time before major surgery.¹⁸

In our study, history of IHD was the only factor independently associated with complications. Unstable angina within 6 months showed trend towards more peri-operative events. Patients undergoing non-cardiac surgery within a year of coronary intervention are at high-risk of morbidity and mortality due to stent thrombosis and its consequences. We had 4 patients who had undergone percutaneous coronary intervention (PCI) within the last year and none had an event.

In patients undergoing elective, intermediate or high-risk surgeries and not having active cardiac conditions, further testing is decided upon the effort tolerance.¹⁹ Patients with poor effort tolerance need further cardiac testing as it is a predictor of poor cardiac outcomes after major surgeries.⁷ In our study, poor effort tolerance was not associated with increased peri-operative complications.

It is our belief that better management of patients before surgery, newer drugs in the armamentarium to treat CHF, diabetes, dyslipidaemia, drugs to retard progression of renal failure could be a major factor in decreasing the impact of these factors on outcomes. Refinement in anaesthetic techniques has its own impact. Many other factors like duration of diabetes, renal failure being more often acute than chronic and CVAs being mostly minor in our study could have led to discrepancies with what is known. Thus, one factor was the only independent predictor in our study compared to four in Lee's study.

Though only IHD is an independent risk predictor, it can still be found that Lee's index is useful in risk stratification. This is obvious as we see the graded relationship between increasing Lee's class and peri-operative cardiac complications; 1.6%, 2%, 6.7%, and 7.7% for Lee's classes I, II, III, and IV, respectively.

Our study is the largest prospective study in our country. We believe Lee's score is useful in peri-operative risk stratification

in patients undergoing surgeries of varying risks. We feel that its predictive accuracy increases with the addition of factors like age, general medical condition, urgency of surgery, and LBBB.

Study limitations

Long-term follow-up of patient was not done.

Only cases deemed at risk by the surgeons or anaesthetists were referred, which included a fraction of cases operated upon in our institute.

Conclusion

The Revise Cardiac Risk Index by Lee et al. is useful in the risk stratification of patients scheduled to undergo non-cardiac surgery. Its accuracy can be improved by the addition of age >70 years, poor general medical condition, emergency surgery, and LBBB on ECG as further risk predictors.

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