

Pre-Operative Cardiac Risk Assessment to Predict Mortality and Intensive Care Admission in Elderly Patients Scheduled for Non-Cardiac Surgery: Comparison of The Revised Cardiac and Geriatric Sensitive Cardiac Risk Indices With Cardiology-Determined Risk

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ABSTRACT

Objective: Pre-operative cardiovascular risk assessment using defined risk indices helps estimate adverse post-operative outcomes and mortality. The available data does not support a single best approach, especially for elderly patients. We aimed to reveal the relationship of cardiac risk indices used pre-operatively with in-hospital mortality and intensive care unit (ICU) admission, with the goal of contributing to a more practical and effective assessment strategy for this growing population.

Materials and Methods: This retrospective single-center study analyzed 503 patients aged over 65 who were assessed preoperatively by cardiology for cardiac risk stratification between June 2023 and June 2024. We assessed the relationship between three cardiac risk indices – cardiologist-determined risk, revised cardiac risk index (RCRI), and geriatric cardiac risk index (GSCRI) – with in-hospital mortality and ICU admission.

Results: A cardiologist's risk assessment revealed no significant ability to predict mortality, with an area under the curve (AUC) of 0.564. In contrast, both the RCRI and the GSCRI showed significant predictive ability, each with an AUC of 0.677. All three cardiac risk indices demonstrated significant effectiveness in distinguishing patients who may require admission to the ICU.

Conclusion: Pre-operative evaluation of the elderly with GSCRI could guide a perioperative patient management plan and predict prognosis, without an overuse of cardiac consultation.

Keywords: Cardiovascular risk assessment, Elderly, Geriatric sensitive cardiac risk index, In-hospital mortality, Intensive care, Revised cardiac risk index

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INTRODUCTION

The perioperative management of cardiovascular disease (CVD) and its complications in patients undergoing non-cardiac surgery has been a focus of research to establish guiding recommendations. Studies indicate that even patients aged 45 and older who undergo in-hospital surgery experience major adverse cardiac events (MACE) in approximately one out of every 33 surgical admissions.^[1] As elderly patients are often at greater risk for cardiovascular problems or developing post-operative CVD, pre-operative evaluation to stabilize or manage these issues presents a more challenging task. Evaluating pre-operative cardiovascular risk indices is recommended to anticipate MACE and mortality.^[2] However, there is insufficient evidence to endorse one index over another, especially for elderly patients. This assessment is crucial for optimizing a perioperative plan, which may include determining the need for intensive care admission.

The revised cardiac risk index (RCRI) is a tool that evaluates the risk of cardiac complications and mortality within 30 days of surgery using six variables.^[3] A score of 3 or higher is associated with a higher risk of mortality, as shown in various studies.^[4] Although it may also predict 1-year mortality, its effectiveness in those over 65 years old is still unclear, except in age-adjusted studies.^[5] Thus, the geriatric cardiac risk index (GSCRI) was developed and validated, proving to be a more effective predictor of 30-day mortality in elderly patients undergoing non-cardiac surgery.^[6] However, the impact of each index on the perioperative patient plan, including the need for post-operative intensive care unit (ICU), has not been examined in practice based on the identified risk. Moreover, in elderly patients with high cardiac risk, pre-operative cardiology consultation is often requested, and post-operative ICU follow-up is planned according to the risk indicated by cardiology for possible post-operative adverse effects. Cardiologists' assessment of risk, although based on the same guideline, may not align with anesthesiologists' evaluations that utilize risk indices such as RCRI and GSCRI in predicting mortality and the risk for post-operative ICU admission.^[2] The risk stratification of a cardiologist primarily relies on patient characteristics, such as a history of CVD, functional capacity assessment, and transthoracic echocardiography results, rather than the extent and timing of surgery.

In this study, we examined the associations of RVRI, GSCRI, and cardiologist-determined risk with in-hospital mortality, the need for post-operative intensive care, and long-term hospitalization in elderly patients undergoing non-cardiac surgery.

MATERIALS AND METHODS

Study Design and Patient Selection

This retrospective cross-sectional cohort study was conducted

at a tertiary-care teaching hospital following approval from our Institutional Ethical Committee (approval number: 57-2024, date: August 1, 2024). We reviewed the records of 607 patients who received pre-operative cardiology consultations between June 2023 and June 2024 from the hospital database. Finally, we included 503 individuals aged 65 years and older who were admitted for elective non-cardiac, non-vascular surgery and had a pre-operative cardiology consultation just because of general evaluation, either for a known chronic cardiac comorbidity or because of anticoagulation management. The exclusion criteria included patients with an American Society of Anesthesiologists (ASA) grade of V or VI, those who experienced a major cardiac event during pre-operative preparation, individuals who had significant intraoperative bleeding that required a blood transfusion, patients who underwent more than one operation during their hospital stay, and files that contained incomplete data. Patient data confidentiality was fully maintained, and the information was utilized solely for research purposes. This study was conducted in accordance with the Helsinki Declaration, and the requirement for informed consent was waived due to the retrospective design of the study.

Clinical Data and Outcome Variables

Demographic variables (age, gender, and ASA score) and clinical characteristics of patients, including smoking status, anticoagulation use, and ejection fraction (EF), written in the cardiology consultation just before the surgery, were noted. Surgical type is classified not by the procedure but by the surgical risk level as minor, moderate, and major, as it is more relevant for cardiac risk stratification. The type of anesthesia was classified as general regional anesthesia, which included spinal and combined spinal epidural anesthesia.

The primary outcome variables of the study are risk assessed by the cardiologist as low, intermediate, or high, determined just before the surgery in the consultation; RCRI and GSCRI were calculated from the medical data received at pre-operative anesthesia evaluation. We also calculated the Charlson comorbidity index (CCI) as an independent estimation of the survival rate. Secondly, we questioned the hospitalization data as to the length of hospital stay, especially extended hospitalization, which is defined as more than 21 days, the type of discharge in search of in-hospital mortality, and the need for ICU admission from the hospital system.

Statistical Analysis

Descriptive statistics of the data included mean, standard deviation, median, minimum, maximum, frequency, and ratio values. The distribution of the variables was assessed using the Kolmogorov–Smirnov and Shapiro–Wilk tests. To analyze quantitative independent data with a non-normal distribu-

tion, the Mann–Whitney U test was employed. The Chi-square test was used for analyzing qualitative independent data. The impact of various factors was examined through univariate and multivariate logistic regression. The effect size and cutoff value were determined using the receiver operating characteristic curve. Statistical analysis was conducted using SPSS version 27.0.

RESULTS

The demographic and clinical characteristics of 503 patients indicated that the majority were male, ASA III patients undergoing major surgery, primarily under general anesthesia (Table 1).

The cardiologist assessed the cardiac risk of the population, categorizing most individuals as low risk. The RCRI primarily indicated a Class 2 risk, whereas the GSCRI revealed mostly a Class 3 risk (Table 2). Furthermore, the mean CCI score in the study population corresponded to a nearly 50% reduction in

the estimated survival rate. The median length of hospital stay was 13 days, and most of the patients were discharged within 21 days (Table 2). Notably, 61.6% of them were admitted to the ICU.

The mortality rate was found to be 22.7% as 93 patients were deceased, and 410 patients were alive. In the multivariate model, significant independent efficacy of gender, general anesthesia, RCRI index, GSCRI index, and EF values were observed in differentiating between patients with and without exitus ($p=0.008, 0.012, 0.027, 0.00, 0.008$). Cardiologist-determined risk showed no significant efficacy in discriminating mortality with an area under the curve (AUC) of 0.564 (0.494–0.635) ($p=0.053$). However, RCRI and GSRI showed significant efficacy in discriminating mortality with an AUC of 0.677 (0.614–0.740) and 0.677 (0.613–0.740) ($p=0.00, p=0.00$), respectively (Fig. 1).

The ASA score, the percentage of general anesthesia, and major surgery were significantly higher in the group that required ICU admission ($p=0.00, 0.00$, and 0.00).

Table 1. Demographic and clinical characteristics of patients			
Variable	Min–Max	Median	Mean±SD/n (%)
Age (years)	65.0–99.0	73.0	74.4±6.9
Gender			
Female			229 (45.5)
Male			274 (54.5)
ASA score			
I			5 (1.0)
II			212 (42.1)
III			222 (44.1)
IV			64 (12.7)
Smoking status			
Non-smoker			134 (26.6)
Former smoker			357 (71.0)
Current smoker			12 (2.4)
Type of anesthesia			
General			405 (80.5)
Regional			98 (19.5)
Surgical risk level			
Major			229 (45.5)
Moderate			121 (24.1)
Minor			153 (30.4)
Ejection fraction (EF, %)	20.0–65.0	55.0	53.3±8.7
Anticoagulant use			
No			255 (50.7)
Yes			248 (49.3)
ASA: Society of Anesthesiologists.			

Table 2. Cardiac risk assessment and hospitalization data			
Variable	Min–Max	Median	Mean±SD/n (%)
Risk assessed by cardiologist			
Low risk			241 (47.9)
Intermediate risk			184 (36.6)
High risk			78 (15.5)
Revised cardiac risk index (RCRI)	0.0–5.0	1.0	1.4±1.1
Geriatric sensitive cardiac risk index (GSCRI)	0.0–73.9	0.3	1.7±4.8
Charlson comorbidity index (CCI score)	2.0–12.0	4.0	4.7±1.8
ICU admission			
Yes			139 (27.6)
No			363 (72.2)
Hospital stay >21 days			
Yes			139 (27.6)
No			363 (72.2)
Length of hospital stay (days)	1.0–143.0	13.0	19.6±21.4 (27.6)
Discharge type			
Discharged home			395 (78.5)
Transferred			14 (2.8)
Exitus			93 (18.5)
ICU: Intensive Care Unit.			

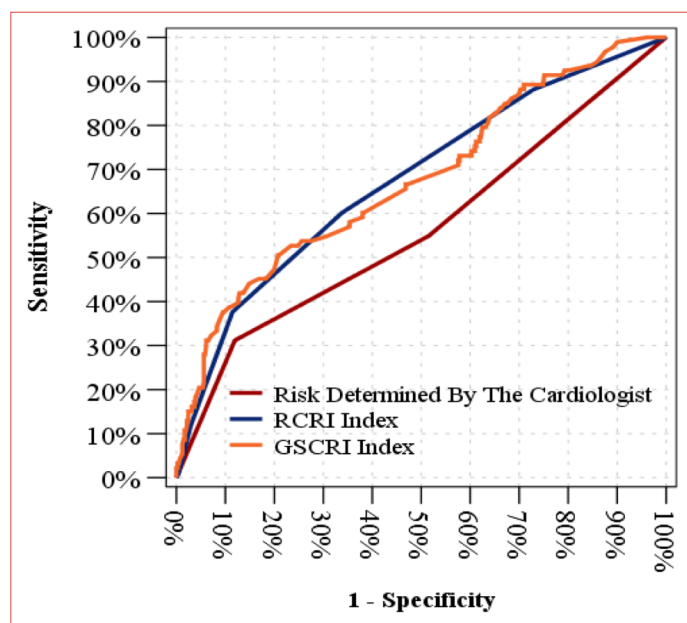


Figure 1. Receiver operating characteristic curves of cardiac risk indices in relation to mortality.

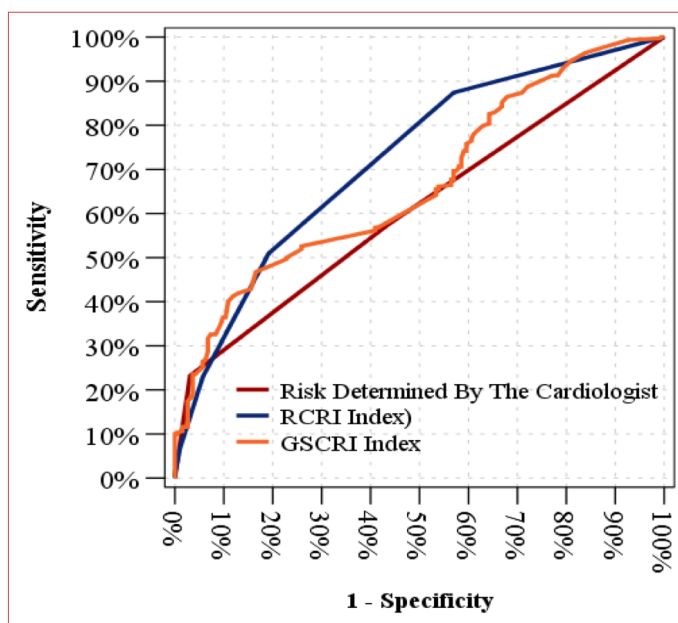


Figure 2. Receiver operating characteristic curves of risk indices in relation to intensive care unit admission.

In the multivariate model, significant independent efficacy of anesthesia type, major surgery, cardiologist-determined risk, RCRI index, GSCRI index, CCI score, and EF value was observed in differentiating patients with and without ICU admission ($p=0.00, 0.00, 0.001, 0.022, 0.002, 0.008, \text{ and } 0.013$). All three cardiac risk indices showed significant efficacy in discriminating possible ICU admission (AUC=0.611, 0.722, and 0.668) (Fig. 2).

DISCUSSION

In this study, we focused on the relation of RCRI and GSCRI, along with cardiologist-determined risk, in predicting patient prognosis for the elderly. Our goal was to determine a practical but reliable perioperative cardiac risk management for the elderly carried out by anesthesiologists and compare the effectiveness between cardiology assessments and the risk indices to predict in-hospital mortality, the need for post-operative intensive care, and long-term hospitalization. Our findings indicate that these risk scores are significantly more effective in predicting in-hospital mortality rates for elderly patients. Furthermore, we have shown that when it comes to the need for post-operative ICU, it is not necessary to rely solely on cardiology assessments. Instead, planning based on the RCRI and GSCRI is both sufficient and adequate.

We specifically selected patients who required cardiology consultation for general evaluation, and most of them requested anticoagulant management regardless of the extent of surgery. Nevertheless, reasons for a pre-operative cardiology consultation may include low exertional capacity, the

need to optimize the treatment of patients showing signs of heart failure, rhythm abnormalities, and evaluation of a newly identified murmur.^[7] In the elderly population, mobility is often limited due to joint diseases, which means that low exertional capacity unrelated to cardiac issues may not accurately reflect risk. For this reason, we did not include the metabolic equivalents (METs) assessment in our study, as it could be misleading, especially since nearly all these patients had a METs score lower than four. Our findings indicated that neither anticoagulant use nor EF was associated with mortality or the need for ICU admission. None of our patients underwent further stress testing, and, in fact, the literature has not found any association between pre-operative stress testing and a reduction in post-operative MACE as well.^[8,9] Therefore, a pre-operative evaluation with RCRI and especially GSCRI could guide a perioperative patient management plan according to risk stratification without an overuse of cardiac consultation.

When or why pre-operative cardiology consultation is necessary is an ongoing debate. In the study of Groot et al.,^[7] most referrals to a cardiologist were found to be for evaluating valve abnormalities, and the cardiologist made no changes to the treatment plan, with the most significant outcome of the cardiac consultation being a delay in surgery. All of the consultations in our case were conducted for a general evaluation, either due to a known chronic cardiac condition or for anticoagulation management. The only outcome from these consultations was the decision to reserve the ICU for a high-risk patient who was scheduled for even a minor surgery. In

fact, as our results show, risk indices can help us make a more accurate prediction of the need for ICU even without a cardiology evaluation. Our finding indicates that the risk assessment determined by cardiology does not predict mortality; however, it does have consequences for ICU admission. Specifically, patients who do not actually require ICU admission might still be reserved for it due to a high-risk assessment made by the cardiologist. As a result, they may end up being admitted to the ICU when it is unnecessary. This situation contributes to increased workload for the hospital and imposes a financial burden on the healthcare system, consistent with other studies in the literature.^[10] Reducing low-value cardiovascular care is a current issue prioritized by the American Heart Association Council on Quality of Care and Outcomes.^[11] It is defined basically as health care services providing no benefit for the patient and also having the possibility of leading to preventable morbidity and mortality, such as unnecessary ICU admission, in the spotlight of this study. To prevent this, Atar et al.^[12] investigated the use of pre-operative risk scores in requesting consultation and found that the Gupta score reduced pre-operative cardiac consultation and diagnostic tests, which in turn reduced operative time and even ICU stays. However, the Gupta score does not include comorbidities other than the creatinine level, which is highly related to prognosis for the elderly.^[6]

This study selected RCRI for the investigation as it is widely accepted and recommended, ensuring a common language among various subspecialties such as surgeons, cardiologists, and anesthesiologists.^[13] RCRI > 1 is associated with increased risk of major cardiac events and also shown to be associated with increased post-operative mortality.^[2,14,15] Moreover, patients with an RCRI score of 1 or greater were found to be related to prolonged hospital stays.^[16] Meanwhile, the higher percentage (72.2%) of our study population did not have a prolonged hospital stay. In studies like this one, where the type of surgery was not analyzed separately, the relationship between a high RCRI and prolonged hospitalization may not be clearly demonstrated. Furthermore, recent studies have raised questions about the limitations of RCRI, particularly in the elderly population, and have explored the development of newer models that are more sensitive in detecting myocardial injury after surgery.^[17] The mean CCI and RCRI values in our patient group also showed the presence of comorbidities, and the elderly group had higher CCI values but lower RCRI values. CCI predicts long-term mortality and needs a different scoring system than RCRI to predict short-term prognosis, as in our patient group.

The GSCRI, developed to more accurately determine surgical and cardiac risk in elderly patients, was found to be more reliable than the GUPTA MICA and RCRI with an AUC of 0.76 in initial validation studies.^[6] When the association of GSCRI with

post-operative MACE in the elderly population in non-cardiac vascular surgeries was examined, the AUC was 0.73, again more sensitive than RCRI, but it did not exceed the limit of 0.80 as in our study, and they augmented its sensitivity by adding NT-proBNP as a biomarker to GSCRI.^[18] What distinguishes the GSCRI from the RCRI is that it considers stroke history and functional status assessment. This is important due to the high incidence of stroke in this age group and the prevalence of frailty, which can lead to mobilization deficits that impact patient prognosis. Recently, frailty has emerged as a crucial factor in decision-making for non-cardiac surgeries.^[19] Additionally, when frailty is combined with the RCRI, it is more effective at predicting perioperative myocardial injury than the RCRI alone.^[20] This may be why the GSCRI is more sensitive than the RCRI in relation to in-hospital mortality and ICU admission, as reflected in our results. The new guideline on cardiovascular management in non-cardiac surgery, published in 2024, essentially recommends estimating the risk of MACEs with a risk calculator without specifying the RCRI or any other single index, as in the previous one, and emphasizes risk modifiers such as frailty and recent stroke in a completely new approach.^[21]

For these reasons, this study examined the GSCRI and found it to be relatively superior to the RCRI. However, as our study examined the elderly defined as 65 years and older, a subgroup analysis was done in 80 years and older, defined as the oldest old, may not have the same results as Fayed et al.^[22] revealed, limited predictive ability of in-hospital MACE and post-operative ICU admission, both for RCRI and GSCRI. Nevertheless, it should be noted that when both risk scores are updated with additional variables such as age, AF, and trauma surgery, the predictability and clinical usefulness of the GSCRI are shown to increase, while the RCRI remains limited.^[22]

Technology is making significant contributions to the healthcare system, particularly through the development of electronic form systems aimed at reducing the number of cardiology consultations needed for cardiac risk assessments.^[23] Researchers are also focusing on developing machine learning algorithms combined with risk indices for assessing risks associated with non-cardiac surgeries.^[24] This area will be the primary focus of future research efforts.

Limitations

Our study has several limitations. First, its retrospective and single-center design limited our ability to collect additional variables that could enhance prognostication and predictive value for this population. For instance, incorporating pre-operative frailty indices would be beneficial. Furthermore, adding the dukes' activity score could help correlate frailty and functional status with their impact on in-hospital mortality and the GSCRI. Assessing cognitive function scores may also

have clinical significance and could broaden research opportunities, particularly for the elderly.

Although we estimated the hospital burden of cardiac consultations, we were unable to provide a precise calculation. This is especially relevant for patients with a low RCRI or GSCRI who require intensive care due to risks identified by cardiology. We could not determine how long the surgery was delayed due to the unavailability of an ICU.

In this study, we did not specifically evaluate the association of pre-operative risk assessments alone with MACE within 30 days without considering intraoperative data, as many variables, such as tachycardia, hypotension, anemia, duration of surgery, and type of anesthesia, may be associated with MACE.

^[20] However, the focus of the study is the pre-operative guidance of risk indices, and to our knowledge, it is the only study in the literature evaluating a comparison of the relation of pre-operative cardiologist-determined risk evaluation and anesthesiologist-determined risk indices on in-hospital mortality and post-operative ICU admission.

CONCLUSION

Predicting post-operative outcomes, especially in elderly patients, is highly effective in determining perioperative patient management. In cases where cardiology consultation is not required, pre-operative GSCRI can predict post-operative prognosis and ICU needs. In this way, proper utilization of hospital resources and necessary precautions in patient management can be ensured. In future studies, a new risk stratification model, augmented by the addition of frailty and cardiac markers, could be developed to increase the sensitivity of the GSCRI.

DECLARATIONS

Ethics Committee Approval: The study was approved by Haseki Training and Research Hospital Ethics Committee (No: 57-2024, Date: 01/08/2024).

Informed Consent: Informed consent was waived due to the retrospective design of the study.

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