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The Relationship Between Revised Cardiac Risk Index and Postoperative Morbidity After Major Abdominal Oncologic Surgery

ABSTRACT

Objectives: Major abdominal surgery is associated with postoperative morbidity, including perioperative cardiac ischemic events. Preoperative risk stratification is important for optimal surgical care, which is only possible once the risk has been identified. We aimed to determine a relationship between the Revised Cardiac Risk Index (RCRI) and postoperative morbidity after major abdominal oncologic surgery.

Methods: Ethics committee approval was obtained by protocol number 2018-04151. A total of 350 patients, aged over 18 years, undergoing elective major abdominal oncologic surgery and were expected to continue for more than two hours participated in the study. ASA classification, RCRI score, duration of surgery, and postoperative morbidity survey (POMS) on postoperative days 1 and 5 were recorded. We followed the length of hospital stay, hospital admissions after discharge, and postoperative mortality within 30 and 90 days.

Results: There was no significant correlation between RCRI and postoperative first-day morbidity (p=0.233). A moderate positive correlation was found between the ASA classification and the RCRI (r=0.443; p<0.001). The patients with high ASA scores had high RCRI scores. The most common morbidities were renal (99,1%), pain (93,7%), and gastrointestinal morbidity (84.3%) on the postoperative first day. As the RCRI score increased, the length of hospital stay was longer; however, this difference was not statistically significant (p=0.180). There was a weak positive correlation between the RCRI score and mortality (r=0.127, p=0.017).

Conclusions: Our study showed an insufficient correlation between RCRI as a preliminary assessment tool and postoperative morbidity. We considered a need for different risk-scoring systems that are practical and useful in predicting patients with a high risk of morbidity after major abdominal oncologic surgery.

Keywords: Major abdominal oncologic surgery, postoperative morbidity survey, revised cardiac risk index

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Morbidity is a more common occurrence after major surgery in high-risk patients. The postoperative mortality rate in the subgroup of high-risk patients is over 80%. This group constitutes more than 15% of the patients undergoing surgery. Advanced age, comorbid disease, major surgery, and emergency surgery are significant factors increasing risk (1,2). Oncologic surgery is one of the high-risk subgroup surgeries. These high-risk patients usually have preoperative risk stratification before undergoing any oncologic intervention.

The techniques and strategies to reduce postoperative adverse outcomes are the basis of the concept of perioperative care. Preoperative exercise programs ("prehabilitation"), optimization of fluid and inotropic therapy, antibiotic therapy, and preoperative anemia treatment are essential components of perioperative care (3,4). The proper use of such resources depends primarily on recognizing "at-high-risk" patients.

Lee's revised cardiac risk index, developed by modifying the Goldman index, is an essential tool for classifying patients into risk categories for postoperative cardiac complications (5). The RCRI is widely used for preoperative risk assessment in non-cardiac surgery (6,7). Few studies investigate the relationship between RCRI and postoperative morbidity in non-cardiac surgery (8-10).

Postoperative morbidity and mortality are some of the most used study endpoints in the lit-

Table 1. Revised Cardiac Risk Index (RCRI)

Criteria	POINT
High-risk surgery Intraperitoneal; intrathoracic, suprainguinal vascular	1 Point
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 Point
History of congestive heart failure Pulmonary edema, bilateral ral or S3 gallop; paroxysmal nocturnal dyspnea; chest x-ray (CXR) showing pulmonary vascular redistribution	1 Point
History of cerebrovascular disease Prior transient ischemic attack (TIA) or stroke	1Point
Pre-operative treatment with insulin	1 Point
Pre-operative creatinine >2 mg/dL / 176.8 µmol/L	1 Point

erature, indicating the quality of surgery and postoperative care. The Postoperative Morbidity Survey (POMS) is the only published prospective method to define short-term morbidity after major surgery (11).

Applying RCRI to risk stratification prior to major cancer surgery has been described in limited literature (12,13). Perioperative risk-mitigation strategies, guided by tools like the RCRI, may improve patient outcomes through better resource allocation and individualized perioperative monitoring or rehabilitation. Therefore, we aim to investigate the association between the RCRI and postoperative morbidity following major abdominal oncologic surgery.

METHODS

The study was conducted in accordance with the Declaration of Helsinki, and ethical approval was obtained from the University of Health Sciences Dr. Abdurrahman Yurtaslan Oncology Training and Research Hospital Ethics Committee (reference number: 2018-04151). Patients were included in the study after they were informed about the study and their consent was obtained. The patients were followed up for 90 days after surgery.

Patient Populations

The study included 350 patients aged >18 years undergoing major abdominal oncologic surgery expected to last longer than two hours. Gastrointestinal (colorectal, pancreatic, gastric surgery), gynecologic cancer (endometrial, ovarian tumor, debulking), and urological surgery (cystectomy, prostatectomy, and nephrectomy) cases were defined as major abdominal oncologic surgery. The exclusion criteria were patients under 18 years of age and those undergoing emergency surgery.

Data Collection

We recorded patient characteristics, American Society of Anesthesiology (ASA) Physical Status Score, Revised Cardiac Risk Index score (RCRI, Table 1), and duration of surgery. Perioperative patient management was performed according to the anesthesiologist's preference. The Postoperative Morbidity Survey (POMS) was recorded by an independent researcher on the postoperative first and fifth day.

The RCRI risk score was calculated by a 1-point assignment for each of the following variables:

1) High-risk surgery (intra-thoracic, vascular, and intra-peritoneal);
2) History of ischemic heart disease;
3) Heart failure;
4) Stroke or transient ischemic attack;
5) Insulin-dependent diabetes mellitus;
6) serum creatinine levels ⩾2 mg/dL for a maximum score of 6 (Table 1).

All patients received at least 1 point on the RCRI as major abdominal surgery for cancer is considered a high-risk intervention.

The POMS, consisting of clinical observation and a questionnaire, is a published method of describing a reliable and valid survey of short-term postoperative morbidity following major surgery (11,14). It is a nine-domain tool, and for each of the nine domains, morbidity is recorded in the presence or absence of preset criteria. POMS are assessed by direct patient interrogation and examination, review of clinical notes and patient follow-up schedules, data from the hospital clinical information system, and consultation with patient caregivers (Table 2).

In-hospital mortality, 30-day and 90-day mortality, admission to the intensive care unit, the length of hospital stay, and re-hospitalization after discharge were recorded.

Statistical Analysis

Patients were categorized into 4 risk classes (1, 2, 3, and ⩾4) depending on the number of preoperative risk factors according to the RCRI (6). Clinical characteristics were summarized and compared between these cohorts. The main hypothesis was to find a correlation between RCRI and POMS. Thus, using the Fisher exact test with four degrees of freedom, we determined that a sample size of 350 patients had a power of 90% to detect an adequate degree of 0.05 (α) and an effect size of 0.2.

Statistical analysis data were evaluated by uploading to the computer via SPSS (Statistical Package for the Social Sciences for Windows v.27.0, SPSS Inc., Chicago, IL). The Kolmogorov-Smirnov test evaluated whether the groups conformed to normal distribution. Categorical variables are reported with percentages, while continuous variables are reported as mean and standard deviation (SD) or median and interquartile range (IQR). Pearson's χ^2 test and Fisher's exact test were used to determine the statistical significance of differences between categorical variables. Results with $p<0.05$ were considered statistically significant.

Table 2. Postoperative Morbidity Survey (POMS)-defined morbidity

Morbidity type	Criteria	Source of data
Pulmonary	Has the patient developed a new requirement for oxygen or respiratory support?	Treatment chart Patient observation
Infectious	Currently on antibiotics and/or has the patient had a temperature of ≥38°C in the last 24 h?	Observation chart Treatment chart
Renal	Does the patient have any of the following: Oliguria (<500 ml day^{-1})? Increased Serum Creatinine (>30% from preoperative level)? Urinary catheter *in situ*?	Fluid balance chart Biochemistry result Treatment chart
Gastrointestinal	Unable to tolerate enteral diet (oral or tube feed)? Is the patient experiencing nausea, vomiting, or abdominal distention? (Use of antiemetic)	Patient questioning Fluid balance chart Treatment chart
Cardiovascular	Has the patient undergone diagnostic tests or therapy within the last 24 h for any of the following: New MI? Ischaemia or hypotension (requiring drug therapy or fluid therapy >200 ml h^{-1})? Atrial or ventricular arrhythmias? Cardiogenic pulmonary oedema/new anticoagulation (warfarin/heparin/fragmin)?	Treatment chart Note review
Neurological	Does the patient have new confusion/delerium, focal deficit, or coma?	Note review Patient questioning
Wound complication	Has the patient experienced wound dehiscence requiring surgical exploration or drainage of pus from the op wound with/without isolation of organisms?	Note review Pathology result
Haematological	Has the patient required any of the following within the last 24 h: rBC/platelets/FFP/cryoprecipitate?	Treatment chart Fluid balance chart
Pain	Has the patient experienced surgical wound pain significant enough to require parenteral opioids or regional analgesia? New postoperative pain significant enough to require parenteral opioids or regional analgesia	Treatment chart Patient questioning

Table 3. Patients characteristics of stratified by the RCRI

Revised Cardiak Risk Index						
	Total (n=350)	**1 (n=222)**	**2 (n=99)**	**3 (n=27)**	**≥4 (n=2)**	**p**
Age (year)	59.9±12.3	56.4±12.1	65.2±9.8	67.5±9.7	79.5±9.1*	**0.001***
ASA classification (n)						**0.001***
I	11	11	0	0	0	
II	209	164	40	5	0	
III	124	46	56	20	2	
IV	6	1	3	2	0	
Duration of surgery (min)	180±70	184±73	174±66	169±57	180±84	0.535
Sex (n) (Female/Male)	172/178	105/117	51/48	15/12	1/1	0.735

RCRI Revised Cardiac Risk Index. n=number of patients. Continuous variables are presented as mean±SD, Categorical variables as count.

RESULTS

This study included 350 patients aged between 19 and 95 (59.9±12.3 years). Patients with a higher RCRI score tended to be older (RCRI≥4: 79.5±9.1 years vs RCRI 1: 56.4±12.1 years, p<0.001). The mean age was significantly lower in patients with an RCRI of 1 than those with RCRI≥2 (p<0.001, Table 3). Hypertension (33.4%), diabetes mellitus (24.3%), and coronary artery disease (11.4%) were the most common comorbidities in the study.

A history of ischemic heart disease was present in 32.2% (118) of the patients, congestive heart failure in 4.6% (16), and a history of cerebrovascular disease in 1.7% (6). Twenty-eight (8.0%) patients were receiving preoperative insulin therapy. Two patients (0.6%) had preoperative creatinine elevation. All patients were in the high-risk surgery group. Demographic distributions, RCRI scores, and ASA classifications of patients according to their operation types are given in Table 3. A moderately positive correlation was found between ASA and RCRI (r=0.443; p<0.001). Patients with high ASA scores also had higher RCRI scores (Table 3).

Postoperative Morbidity

While there was no significant correlation between RCRI and postoperative first-day morbidity (p=0.196, r=0.06), a weak positive cor-

Table 4. Postoperative Morbidity Incidence

Variables n (%)	First day morbidity	Fifth day morbidity
Pulmonary Morbidity	17 (%4.9)	23 (%6.6)
Infectious Morbidity	27 (%7.7)	64 (%18.3)
Renal Morbidity	347 (%99.1)	86 (%24.6)
Gastrointestinal Morbidity	295 (%84.3)	107 (%30.6)
Cardiovascular Morbidity	19 (%5.4)	17 (%4.9)
Neurological Morbidity	5 (%1.4)	2 (%0.6)
Wound Morbidity	5 (%1.4)	6 (%1.7)
Hematological Morbidity	44 (%12.6)	22 (%15.7)
Pain Morbidity	328 (%93.7)	55 (%15.7)

Variables were given as n (%).

relation was found between RCRI and morbidity on the fifth postoperative day (r=0.13; p=0.01). The most common morbidities were renal (99.1%), pain (93.7%), and gastrointestinal morbidity (84.3%) on the postoperative first day (Table 4). Gastrointestinal and renal morbidities were found to be the most common on the fifth postoperative day (Table 4). The frequency of cardiovascular morbidity on the fifth postoperative day was higher in patients with an RCRI≥3 compared to those with scores of 1 and 2 (p=0.012, Table 5).

Discharge Data

The mean length of hospital stay was 10.11±8.3 days (Table 6). The length of hospital stay was longer in patients with a higher RCRI, but the difference was not statistically significant (p=0.180). The number of patients requiring intensive care was 28 (8%). Thirty-three patients (9.4%) were readmitted within 30 days after dis-

Table 5. Postoperative Morbidity Survey by RCRI

Postoperative morbidity survey, Variables n (%)	RCRI 1 (n=222)	RCRI 2 (n=99)	RCRI 3 (n=27)	RCRI ≥4 (n=2)	p
Pulmonary morbidity					
- Postoperative first day	8 (3.6)	6 (6.1)	2 (7.4)	1 (50)	0.269
- Postoperative fifth day	11 (5.0)	7 (7.1)	4 (14.8)	0 (0)	0.106
Infectious morbidity					
- Postoperative first day	19 (8.6)	6 (6.1)	1 (3.7)	1 (3.7)	0.472
- Postoperative fifth day	39 (17.7)	18 (18.2)	7 (25.9)	0 (0)	0.531
Renal morbidity					
- Postoperative first day	219 (98.6)	99 (100)	27 (100)	2 (100)	0.655
- Postoperative fifth day	51 (23)	27 (27.3)	8 (29.6)	0 (0)	0.614
Gastrointestinal morbidity					
- Postoperative first day	185 (83.3)	84 (84.8)	24 (88.9)	2 (100)	0.824
- Postoperative fifth day	58 (26.4)	36 (36.3)	12 (44.4)	1 (50)	0.061
Cardiovascular morbidity					
- Postoperative first day	11 (5.0)	7 (7.1)	1 (3.7)	0 (0)	0.745
- Postoperative fifth day	8 (3.6)	4 (4.1)	5 (18.5)	0 (0)	**0.012***
Neurological morbidity					
- Postoperative first day	3 (1.4)	2 (2.0)	0 (0)	0 (0)	0.761
- Postoperative fifth day	1 (0.5)	1 (1.0)	0 (0)	0 (0)	0.592
Wound morbidity					
- Postoperative first day	4 (1.8)	1 (1.0)	0 (0)	0 (0)	0.858
- Postoperative fifth day	5 (2.2)	1 (1.0)	0 (0)	0 (0)	0.758
Hematological morbidity					
- Postoperative first day	18 (8.2)	21 (21.2)	5 (18.5)	0 (0)	**0.004***
- Postoperative fifth day	14 (6.4)	5 (5.1)	2 (7.4)	1 (50)	0.762
Pain morbidity					
- Postoperative first day	208 (93.7)	94 (95.9)	24 (88.9)	2 (100)	0.344
- Postoperative fifth day	29 (13.2)	17 (17.3)	8 (29.6)	1 (50)	0.076

Data are given as n (%). n: number of patients.

Table 6. Discharge Parameters

	Revised Cardiak Risk Index				
	Total (n=350)	**1 (n=222)**	**2 (n=99)**	**3 (n=27)**	**≥4 (n=2)**	**P**
Length of hospital stay (day)	10.1± 8.3	9.7±8.2	10.7±9.3	10.1±6.7	12±2.8	0.180
Patient readmitted within 30 days (n)	33	25	8	0	0	0.252
In-hospital mortality, n (%)	3 (0.8)	1 (0.4)	0 (0)	2 (7.4) *	0 (0)	**<001***
30-day mortality, n (%)	6 (1.7)	3 (0.8)	0 (0)	3 (11) *	0 (0)	**<001***
90-day mortality, n (%)	10 (2.9)	4 (1.8)	1 (1)	5 (18.5) *	0 (0)	**<001***

Continuous variables are presented as mean±SD ; categorical variables as count (percentage), number of patients n= (%). *RCRI 3 compared to RCRI 1 and 2.

charge. There was no statistically significant correlation between the RCRI and the length of hospital stay (Table 6, r=0.09, p=0.06).

Mortality Data

The hospital mortality rate was 0.8%, and the 90-day mortality was 2.9%. The mortality rate was significantly higher in patients with an RCRI≥3 (18.5%) compared to those with an RCRI≤2 (1.5%) (p<0.001, Table 6) for 90-day mortality. There was a weak positive correlation between mortality and both RCRI and ASA scores (respectively, r=0.127; p=0.017, and r=0.224; p<0.001).

DISCUSSION

The study demonstrated that the RCRI was insufficient for predicting postoperative morbidity following major abdominal surgery, with non-cardiac morbidity being more common than cardiac morbidity.

The RCRI is one of the best predictors of cardiac risk in non-cardiac surgery and has been utilized in various studies to predict non-cardiac postoperative morbidity (8-10). Ackland et al. (8) found an association between the RCRI and postoperative morbidity, as well as prolonged hospital stays in elective orthopedic surgery. However, our study could not demonstrate a relationship between RCRI and morbidity.

Previous studies have indicated an association between a high RCRI and extended hospital stays. (8,11,14) The mean hospitalization time for our patients was 10.11±8.3 days. Although hospital stay lengthened as ASA and RCRI scores increased, there was no significant relationship between the mean hospital stay and ASA and RCRI scores.

The in-hospital mortality rate was 0.8% in our study, lower than the 1.5% reported in the cohort study by Lee et al., (6) which evaluated 1422 patients. They considered cardiac events and examined patient groups with varying postoperative morbidities, including major vascular surgeries. Our study focused on a homogeneous patient group with similar operation times and expected postoperative morbidity levels.

The 90-day mortality rate was higher at 18.5% in patients with an RCRI of ≥3 in our study. Jakobson et al. (2) observed a 3-month mortality rate of 17.8% in patients with an RCRI of ≥3 in major gastrointestinal surgery. The adverse impact of a higher ASA physical status and revised cardiac risk index on short-term mortality is well-documented (15-17). The long-term survival of patients undergoing major abdominal surgery for malignancy is influenced by numerous factors, such as the presence or development of postoperative complications, whether the surgery was radical or palliative, and comorbidities. Both short- and long-term mortality rates were significantly higher in patients with postoperative complications. Our study indicated that high ASA and RCRI scores are associated with long-term mortality.

In the past, retrospective data analysis was frequently used to evaluate the type and frequency of complications. However, this approach may be inadequate for assessing the frequency and accuracy of complications due to many methodological limitations (18). The Postoperative Morbidity Survey (POMS) is the only published prospective method to identify short-term morbidity after major surgery and has been substantiated by reliable validity research (11,19). Nevertheless, POMS has its limitations, as it includes parameters such as postoperative oxygen and urinary catheterization, which are accepted as routine after major surgery. Consequently, in our study, the most common morbidity on the first postoperative day was renal morbidity, primarily due to routine urinary catheterization. Howes et al. (14) modified POMS by excluding the presence of urethral catheterization alone and pain as diagnostic criteria in their study. When oliguria and an increase in serum creatinine were used as criteria, renal morbidity was reported as 11.8%. If we had excluded data from routine urinary catheterization in our study, renal morbidity would have been 6% on the first postoperative day.

Postoperative gastrointestinal dysfunction is approximately doubled in patients undergoing laparotomy, with mechanical trauma playing a crucial role in this complication (20,21). Gastrointestinal system morbidity was the most common fifth-day morbidity at 30% in our study. Occult hypovolemia from fluid losses and bleeding is common after major surgery, disrupting global oxygen delivery. Compensatory splanchnic vasoconstriction maintains blood flow to vital organs, leaving the gastrointestinal tract vulnerable to ischemia (22,23). A limitation of our study was its observational nature; we could not standardize critical parameters that may cause gastrointestinal complications, such as intraoperative fluid management and the use of non-steroidal anti-inflammatory drugs. Intraoperative hemodynamic changes were not evaluated.

It has been reported that cardiac complications are the most common morbidity after non-cardiac surgery (24-26). However, in our study, cardiovascular morbidity was less frequent than other types of morbidity but was associated with poor outcomes. Similar to our findings, Ackland et al. (8) indicated that non-cardiac morbidity was more prevalent than cardiac morbidity. Notably, high rates of cardiovascular complications (18%) developed in patients with a high RCRI score, underscoring RCRI as a robust index for classifying patients into risk categories to predict cardiovascular complications, as recommended by guidelines.

CONCLUSION

The incidence of complications after major abdominal surgery is substantial, markedly increasing postoperative morbidity, mortality, and hospital stay duration. In practice, the assessment of risk assessment methods is challenging due to performance bias: the identification of high-risk individuals can lead to significant disparities in care, potentially equalizing the postoperative mortality and morbidity rates of these patients with those at lower risk. The RCRI does not adequately reflect the risk of postoperative morbidity, while the ASA and increased RCRI scores do reflect the risk of mortality. The number of patients with RCRI≥3,4 was low in our study, suggesting a need for further research involving more patients with high RCRI scores. Another limitation was our failure to evaluate preoperative anemia, intraoperative bleeding, and intraoperative events.

Our results did not detect an association between RCRI and postoperative mortality, contrary to existing literature. We advocate for practical and convenient risk-scoring systems to predict high-risk patients and enhance perioperative care quality. Risk-scoring tools may lead to better outcomes when considering intraoperative events at the operation's end.

Ethics Committee Approval: This study was conducted with the permission of the University of Health Sciences Dr. Abdurrahman Yurtaslan Oncology Training and Research Hospital Local Ethics Committee (decision no: 2018-04/51, date: 18.04.2018).

Informed Consent: Written informed consent was obtained from the patients who agreed to take part in the study.

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