Al-Azhar International Medical Journal

Volume 4 | Issue 1 Article 19

1-2023

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How to Cite This Article

Mohammed, Mohammed Suleiman; Atia, Wael Mohammed; and Zahran, Al Hussein Mustafa (2023) "Preoperative Right Ventricular Echocardiographic Parameters Predict Perioperative Cardiovascular Complications in Patients Undergoing High risk Non-Cardiac Surgery," *Al-Azhar International Medical Journal*: Vol. 4: Iss. 1, Article 19.
DOI: https://doi.org/10.58675/2682-339X.1637

CASE SERIES

Preoperative Right Ventricular Echocardiographic Parameters Predict Perioperative Cardiovascular Complications in Patients Undergoing High-Risk Noncardiac Surgery

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Abstract

Background: **Every year, 200 million people worldwide undergo major noncardiac surgery (NCS), and 10 million people experience a significant cardiac problem during the first 30 days following NCS. Perioperative cardiovascular complications (PCCs) are extremely significant as they contribute to at least one-third of perioperative mortality, lengthen hospital stays, and raise medical expenses.**

Objective: **The aim was to investigate the importance of presurgical right ventricular (RV) echocardiographic parameters in the prediction of PCCs in individuals having high-risk NCS.**

Patients and methods: **In this prospective cohort observational trial, 200 patients who were all potential candidates for high-risk, noncardiac operations between October 2020 and June 2021 were included. Patients were allocated preoperatively into one group and postoperatively into two groups according to the presence of postoperative cardiac complications.**

Results: **The incidence of PPCs among the study population was about 36 patients of 200 patients with percentage of 18%. The results also revealed that significant predictors of postoperative PCCs after major NCS arranged by descending manner according to their odds ratio are as follows: Tie index greater than 0.47, tricuspid valve E/A (TV E/A) less than or equal to 1.18, tricuspid annular plane systolic excursion less than or equal to 1.8, MV E/A less than or equal to 1.3, left ventricular ejection fraction (LVEF) (%) less than or equal to 56, LVESDV (ml^3) greater than 35.6, HbA1C greater than 7.7, MV E/e′ greater than 8.32, revised cardiac risk index, RV fractional area change (%) less than or equal to 35.6, mitral regurgitation (MR) up to moderate, serum creatinine (mg/dl) greater than 1.4, left atrial volume index (LAVI) greater than 22, and serum urea (mg/dl) greater than 34. By multivariate analysis, the authors found that the significant risk factors for PCCs are LVEF (%) less than or equal to 56, TV E/A less than or equal to 1.18, and Tie index greater than 0.47.**

Conclusion: **RV echocardiographic measures taken before surgery are independent risk factors for PCCs in individuals having major NCS.**

Keywords: Noncardiac surgery, Perioperative cardiovascular complications, Right ventricular echocardiographic

1. Introduction

Every year, 200 million people worldwide have major noncardiac surgery (NCS), and 10 million people experience a significant cardiac problem during the first 30 days following NCS.[1] Perioperative cardiovascular complications, or PCCs, are extremely significant as they contribute to at least one-third of perioperative mortality, lengthen hospital stays, and raise medical expenses.[2]

Cardiovascular events are influenced by patient-related risk factors, surgery type, and conditions of operation. Approximately 1−5% of cardiac events

Accepted 18 August 2022.
Available online 15 May 2023

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https://doi.org/10.58675/2682-339X.1637

have been observed in patients receiving intermediate-risk or high-risk noncardiac surgeries. The assessment of cardiac function and structure is done using the simple, noninvasive method known as transthoracic echocardiography (TTE). However, there has been no agreement on how to evaluate perioperative risk comprehensively. Many investigations have not confirmed the routine usage of preoperative TTE for cardiac risk assessment before major NCS as measurements of echocardiographic parameters do not have superior predictive ability to clinical risk factors.[3]

Both surgery and anesthesia are regarded as risk factors for inflammation, sympathetic nervous system activation, and hypercoagulability, all of which may result in PCCs.[4]

Accurate presurgical PCC risk estimation is critical for informing patients about the advantages and disadvantages of surgery, making decisions regarding the sort of surgery or an esthetic, and deciding on the intensity of postsurgical care.[5]

For the estimation of PCC risk, a number of risk indices were created and validated. Previous research has demonstrated, however, that clinical risk indices can ignore perioperative risk in certain cases. Owing to this restriction, recent research has looked at the prognostic significance of noninvasive cardiac tests before surgery and cardiac biomarkers.[6]

One of the most commonly used imaging techniques for the diagnosis of cardiovascular diseases is TTE. Present guidelines recommend presurgical cardiac stress echocardiography in patients with decreased functional ability who are thought to have a risk of severe advanced cardiac events of more than 1% based on clinical criteria.[1]

Additionally, a newly published retrospective study that included patients from throughout the country found that presurgical TTE did not reduce in-hospital death or postsurgical complications in patients receiving surgical therapy for hip fractures. Although in clinical practice it is popular, given the contradictory findings of the aforementioned research, present guidelines do not recommend routine presurgical cardiac evaluation by TTE for everyone.[7]

Additionally, all observational studies assessing the effect of TTE on perioperative results in patients receiving NCS have focused on the function of the left ventricle (LV), hypertrophy of the LV, and valvular dysfunction.[8]

In patients experiencing stable heart failure, right ventricular (RV) ejection fraction was shown to be an independent indicator of survival. Patients experiencing decreased RV function and concurrent LV failure had poorer results following coronary artery bypass surgery. In the most recent practice guidelines, the assessment of RV ejection fraction is not frequently done as a presurgical risk classification of patients having cardiac surgery.[9]

Although there is an increasing indication that preoperative RV function is a critical predictor of perioperative cardiac surgical complications, the importance of RV echocardiographic parameters after NCS, independent of LV indicators, is uncertain.[6]

The significance of RV diastolic and systolic echocardiographic measures as a predictive tool in patients experiencing symptomatic heart failure has already been demonstrated.[10]

Before surgery, RV dysfunction can be identified by echocardiography, and thus, it provides a relatively simple, noninvasive, and efficient method to identify high-risk patients.[11] Recent research has demonstrated that the RV function echocardiographic parameters are a predictor of perioperative death in patients having valvular cardiac operations.[12,13]

The goal of this study was to investigate the importance of presurgical RV echocardiographic parameters in the prediction of PCCs in individuals having high-risk NCS.

2. Patients and methods

In this prospective cohort, observational analytical investigation, adult patients who had undergone major or high-risk noncardiac surgeries at El Sahel Teaching Hospital and Al-Azhar University Hospitals in Cairo during the period between October 2020 and June 2021 were included. This study included 200 patients who were all candidates for major or high-risk NCS. Patients were submitted preoperatively into one group and postoperatively into two groups according to presence of postoperative cardiac complications as follows: group A patients without postoperative cardiac complications and group B patients with postoperative cardiac complications.

Patients were enrolled according to the following criteria: with respect to cardiac risk, patients who were candidates for high-risk noncardiac surgeries, which include high-risk open or endovascular procedures, with 30-day cardiac event risks (cardiac mortality and myocardial infarction) estimated at 5%, such as aortic and vascular operations, open lower extremity revascularization or ambulation of thromboembolectomy, duodenopancreatic surgery, hepatic excision and bile duct surgery, esophagectomy, repair of perforated bowel, adrenal excision, pneumonectomy, total cystectomy, and liver or pulmonary transplant. However, we excluded

patients who refused to give their written informed consent, patient who will undergo low-risk or intermediate-risk surgeries, patients with liver cell failure, patients with recent myocardial ischemia, patients suffering from bleeding tendency, patients will undergo cardiac surgeries, patients who were diagnosed as having right-sided heart failure with or without pulmonary hypertension, patients who are contraindicated for surgery, patients with a less than 50% LV ejection fraction, and those with valvular heart diseases.

Noninvasive cardiac tests are often performed to refine clinical risk assessments in the preoperative setting, but currently used noninvasive tests offer only minimal help in assessment of risk for these patients. TTE is readily available, costs less than other noninvasive stress tests, and involves no intravenous injections or exposure to radiation.

In this study, all patients were assessed preoperatively after obtaining their written informed consent by collection of patient demographic data, complete history taking regarding cardiovascular risk factors, and cardiac symptoms. Moreover, preoperative laboratory tests, 12-lead ECG, and preoperative imaging were done. Patients underwent comprehensive preoperative TTE. Using the tools available, standard parasternal and apical images were acquired in the left lateral decubitus posture. All echocardiographic measurements were taken in accordance with the American Society of Echocardiography/European Association of Cardiovascular Imaging Guidelines.[1,2]

LV volumes and ejection fraction were assessed, as well as the mitral peak E and A wave velocities, which were obtained from the apical four-chamber view by positioning the pulsed-wave Doppler sample volume among the mitral leaflet tips, and the e′ velocity for pulsed-wave tissue Doppler imaging, which was obtained by positioning the pulsed-wave Doppler sample volume in the lateral mitral basal region. The index of left atrial volume is computed by dividing the volume of the left atrium by the body surface area.

Two-dimensional echocardiography revealed RV diameters in the apical four-chamber view. Planimetry was used to measure the right atrial region at the end of systole in the apical four-chamber view. In the RV focused view, the basal RV diameter was determined in the basal third of the RV inflow at the end of diastole.

The RV focused view's right RV is traced at the ends of diastole and systole to measure the right ventricular fractional area change (RV FAC). We assessed RV diastolic function by measuring the tricuspid inflow velocity throughout early diastolic filling (E) and late diastolic filling velocity caused by atrial contraction (A), employing apical four-chamber views as well as recordings of pulse waves at the level of the annulus of the tricuspid leaflet tips.[6]

Calculated at the lateral tricuspid annulus is the ratio of the E wave of the tricuspid inflow to the e′ wave acquired via tissue Doppler. The maximum velocity of tricuspid regurgitation is used to compute the peak systolic pulmonary arterial pressure, which is then computed by adding the right atrial pressure estimation to the gradient of the systolic transtricuspid pressure. Using Doppler echocardiography, the RV Tei-index was determined in all cases as earlier described. Using two-dimensional echocardiography to guide M mode recording from the apical four-chamber view with the cursor positioned at the free wall side of the tricuspid annulus, researchers were able to calculate the tricuspid annular plane systolic excursion (TAPSE), an index of RV systolic function.[1,6]

Major PCC was the study's primary finding. PCCs have been characterized as severe arrhythmias that require therapy, acute cardiac failures, acute coronary syndromes (unstable angina or nonfatal acute myocardial infarction), pulmonary thromboembolism, nonfatal cardiac arrests, cardiac mortality, and cardioembolic strokes. The definition of severe arrhythmias that required therapy included supraventricular or ventricular tachycardia lasting 30 s or more and requiring medication, atrioventricular block requiring medication, and pacemaker placement.

2.1. Statistical analysis

Statistical Package for the Social Sciences version 20.0 (SPSS Inc., Chicago, Illinois, USA) of was used to analyze the recorded data. The mean ± SD was employed to express quantitative data. Frequencies and percentages were employed to express qualitative data.

The following tests were carried out:

(1) Independent-samples *t*-test of significance was employed when comparing between two means.
(2) The acceptable margin of error was set at 5%, and the confidence interval was set at 95%. The *P* value was therefore deemed significant as follows:

P values lower than 0.05 were deemed significant.

P values lower than 0.001 were deemed highly significant.

P values greater than 0.05 were deemed insignificant.

Table 1. Comparison of the groups with and without PCCs based on patient demographic data.

	No PCC ($N = 164$)	PCC ($N = 36$)	Test value	P value	Significance
Age					
Mean ± SD	56.90 ± 11.59	57.56 ± 11.41	−0.310	0.757	NS
Range	28–81	38–78			
Sex [n (%)]					
Female	72 (43.9)	22 (61.1)	3.509	0.061	NS
Male	92 (56.1)	14 (38.9)			

PCC, perioperative cardiovascular complication.

3. Results

The analysis of our statistical results shows that the patients' mean age was 57.02 ± 11.54 year, 47% were females and 53% were males, diabetic patients represented 51%, hypertensive patients represented 49%, patients with ischemic heart disease represented 28%, patients with heart failure represented 13%, patients with atrial fibrillation represented 16.5%, 16.5% had history of cerebrovascular stroke, patients with chronic obstructive pulmonary disease represented 19.5%, patients with peripheral vascular disease represented 11%, 32.5% of patients were smokers, and patients with dyslipidemia represented 19% (Table 1).

Our results show no statistically significant differences among between with and without PCCs according to preoperative history and risk factors apart from the history of AF, where 14% of patients without PCCs had a history of atrial fibrillation (AF), whereas it was 27.8% in the group with PCCs, as shown in Table 2.

Preoperative laboratory analysis shows statistically significant differences in serum urea, creatinine, and HbA1C between the PCC group and the non-PCC group, as shown in Table 3.

The analysis of our results shows highly significant results for left ventricular end systolic and diastolic volume (LVESDV), left ventricular ejection fraction (LVEF), mitral valve E/A (MV E/A), and left

Table 2. Comparison of the groups with and without PCCs based on preoperative history and risk factors.

Risk factors	No PCC ($N = 164$) [n (%)]	PCC ($N = 36$) [n (%)]	Test value	P value
DM				
No	82 (50.0)	16 (44.4)	0.365	0.546
Yes	82 (50.0)	20 (55.6)		
HTN				
No	86 (52.4)	16 (44.4)	0.755	0.385
Yes	78 (47.6)	20 (55.6)		
IHD				
No	118 (72.0)	26 (72.2)	0.001	0.974
Yes	46 (28.0)	10 (27.8)		
HF				
No	144 (87.8)	30 (83.3)	0.522	0.470
Yes	20 (12.2)	6 (16.7)		
AF				
No	**141 (86.0)**	**26 (72.2)**	**4.053**	**0.044**
Yes	**23 (14.0)**	**10 (27.8)**		
CVS				
No	140 (85.4)	27 (75.0)	2.302	0.129
Yes	24 (14.6)	9 (25.0)		
COPD				
No	135 (82.3)	26 (72.2)	1.916	0.166
Yes	29 (17.7)	10 (27.8)		
PVD				
No	146 (89.0)	32 (88.9)	0.001	0.981
Yes	18 (11.0)	4 (11.1)		
Smoking				
No	113 (68.9)	22 (61.1)	0.817	0.366
Yes	51 (31.1)	14 (38.9)		
Dyslipidemia				
No	136 (82.9)	26 (72.2)	2.198	0.138
Yes	28 (17.1)	10 (27.8)		

COPD, chronic obstructive pulmonary disease; CVS, cerebrovascular stroke; DM, diabetes mellitus; HF, heart failure; HTN, hypertension; IHD, ischemic heart disease; PCC, perioperative cardiovascular complication; PVD, peripheral vascular disease.

Table 3. Comparison of the groups with and without PCCs based on preoperative laboratory data.

	No PCC ($N = 164$)	PCC ($N = 36$)	Test value	P value	Significance
Hb (mg/dl)					
Mean ± SD	13.01 ± 1.89	12.99 ± 2.13	0.064	0.949	NS
Range	9.5–17.2	9.5–17			
Hct (%)					
Mean ± SD	35.49 ± 3.96	35.88 ± 4.34	−0.528	0.598	NS
Range	27–46	28–45			
Serum urea (mg/dl)					
Median (IQR)	28 (21.5–37.5)	35 (25–46.5)	−2.098	0.036	S
Range	13–78	14–70			
Serum creatinine (mg/dl)					
Median (IQR)	1.1 (0.71–1.35)	1.24 (0.95–1.7)	−2.666	0.008	HS
Range	0.25–13	0.55–3.5			
SGPT (mg/dl)					
Mean ± SD	28.00 ± 10.43	27.75 ± 7.10	0.137	0.891	NS
Range	15–70	15–44			
SGOT (mg/dl)					
Mean ± SD	45.23 ± 15.35	44.56 ± 10.91	0.251	0.802	NS
Range	25–115	30–75			
HbA1C					
Mean ± SD	7.31 ± 0.92	8.26 ± 1.37	−3.695	0.000	HS
Range	6–11.5	6.1–11			

Hb, hemoglobin; HbA1C, glycated hemoglobin; Hct, hematocrit; HS, highly significance; IQR, interquartile range; PCC, perioperative cardiovascular complication; S, significance; SGOT, serum glutamic-oxaloacetic transaminase; SGPT, serum glutamic-pyruvic transaminase.

atrial volume index (LAVI) ($P = 0.000$) and significant result for presence of mitral regurgitation (MR) up to moderate ($P = 0.028$), and also there was a significant result for MV E/e′($P = 0.042$), as shown in Table 4.

The analysis of right-side data shows highly significant results for RV FAC (%), TAPSE, tricuspid valve E/A (TV E/A), TV E/e′, and Tie index ($P = 0.000$), and also revised cardiac risk index shows highly significant result, as shown in Table 5.

From our univariate analysis, we can conclude that significant risk factors (predictors) of postoperative PCCs after major noncardiac surgeries arranged by descending manner according to their odds ratio are as follows: Tie index greater than 0.47 ($P = 0.000$; odds ratio = 238.333), TV E/A less than or equal to 1.18

Table 4. Comparison between PCC group and non-PCC group according to preoperative left-side data.

	No PCC ($N = 164$)	PCC ($N = 36$)	Test value	P value	Significance
LVEDV (ml)					
Mean ± SD	86.81 ± 12.55	90.48 ± 12.20	−1.598	0.112	NS
Range	67–145	68–151			
LVESDV (ml)					
Mean ± SD	33.89 ± 5.74	40.35 ± 6.79	−5.910	0.000	HS
Range	23.9–59	27–72			
LVEF (%)					
Mean ± SD	60.41 ± 3.77	55.72 ± 3.24	6.923	0.000	HS
Range	53–70	52–64			
MV E/A					
Mean ± SD	1.41 ± 0.15	1.13 ± 0.20	9.573	0.000	HS
Range	0.8–1.8	0.8–1.5			
MV E/e′					
Mean ± SD	9.49 ± 1.99	10.23 ± 1.80	−2.050	0.042	S
Range	6.3–15.3	7.4–14			
MR up to moderate					
No	157 (95.7)	31 (86.1)	4.844	0.028	S
Yes	7 (4.3)	5 (13.9)			
LAVI					
Mean ± SD	23.74 ± 3.70	25.61 ± 4.04	−2.705	0.007	HS
Range	16–32	18–38			

HS, highly significance; PCC, perioperative cardiovascular complication; S, significance.

Table 5. Comparison between PCC group and non-PCC group according to preoperative right-side data.

	No PCC ($N = 164$)	PCC ($N = 36$)	Test value	P value	Significance
RA area (cm^2)					
Mean ± SD	14.52 ± 1.02	14.53 ± 1.05	−0.060	0.952	NS
Range	11.6–17.1	12.5–16.92			
RV bas diam (mm)					
Mean ± SD	37.09 ± 3.55	36.66 ± 3.50	0.670	0.503	NS
Range	28–49.4	27–44			
RV FAC (%)					
Mean ± SD	38.58 ± 3.53	36.31 ± 3.27	3.541	0.000	HS
Range	30–51	30–44			
TAPSE (cm)					
Mean ± SD	2.12 ± 0.23	1.68 ± 0.10	10.805	0.000	HS
Range	1.58–2.55	1.49–1.9			
TV E/A					
Mean ± SD	1.56 ± 0.23	1.20 ± 0.29	8.199	0.000	HS
Range	1–2	0.79–2			
TV E/e′					
Mean ± SD	5.02 ± 0.91	6.58 ± 1.05	−9.019	0.000	HS
Range	4–9.02	4–8.7			
Tie index					
Mean ± SD	0.40 ± 0.07	0.56 ± 0.05	−13.855	0.000	HS
Range	0.25–0.58	0.35–0.61			
ESPAP (mm Hg)					
Mean ± SD	27.40 ± 5.90	28.64 ± 6.33	−1.124	0.262	NS
Range	16–47	18–41			
Revised cardiac risk index					
2	105 (64.4)	5 (13.9)	45.014	0.000	HS
3	45 (27.6)	14 (38.9)			
4	13 (8.0)	17 (47.2)			

ESPAP, end systolic pulmonary artery pressure; HS, highly significance; PCC, perioperative cardiovascular complication.

($P = 0.000$; odds ratio = 63.600), TAPSE less than or equal to 1.8 ($P = 0.000$; odds ratio = 61.600), MV E/A less than or equal to 1.3 ($P = 0.000$; odds ratio = 18.429), LVEF (%) less than or equal to 56 ($P = 0.000$; odds ratio = 15.222), LVESDV (ml^3) greater than 35.6 ($P = 0.000$; odds ratio = 8.898), HbA1C greater than 7.7($P = 0.000$; odds ratio = 7.042) MV E/e′ greater than 8.32 ($P = 0.002$; odds ratio = 5.388),

Table 6. Univariate analysis for categorical risk factors of PCCs among the patients with PCCs.

	B	SE	Wald	P value	Odds ratio (OR)	95% CI for OR	
						Lower	Upper
AF	0.858	0.435	3.892	**0.049**	2.358	1.006	5.528
Serum urea (mg/dl) > 34	1.076	0.377	8.140	**0.004**	2.932	1.400	6.139
Serum creatinine (mg/dl) > 1.4	1.266	0.392	10.452	**0.001**	3.547	1.646	7.641
HbA1C > 7.7	1.952	0.556	12.330	**0.000**	7.042	2.369	20.932
LVESDV (m^3) >35.6	2.186	0.476	21.097	**0.000**	8.898	3.501	22.615
LVEF (%) ≤56	2.723	0.439	38.514	**0.000**	15.222	6.442	35.969
MV E/A ≤1.3	2.914	0.486	35.929	**0.000**	18.429	7.107	47.785
MV E/e′ >8.32	1.684	0.554	9.251	**0.002**	5.388	1.820	15.949
MR up to moderate	1.286	0.618	4.334	**0.037**	3.618	1.078	12.138
LAVI >22	1.102	0.450	5.997	**0.014**	3.009	1.246	7.267
RV FAC (%) ≤35	1.357	0.394	11.842	**0.001**	3.886	1.794	8.418
TAPSE ≤1.8	4.112	0.584	49.611	**0.000**	61.053	19.445	191.692
TV E/A ≤1.18	4.153	0.576	52.052	**0.000**	63.600	20.584	196.512
TV E/e′ >8.32	2.261	1.239	3.328	0.068	9.588	0.845	108.774
Tie index >0.47	5.474	1.041	27.660	**0.000**	238.333	30.995	1832.661
Revised cardiac risk index	1.638	0.284	33.332	**0.000**	5.143	2.949	8.966

CI, confidence interval; HbA1C, glycated hemoglobin; PCC, perioperative cardiovascular complication; RV FAC, right ventricular fractional area change.
P values lower than 0.05 were deemed significant.
P values lower than 0.001 were deemed highly significant.
P values greater than 0.05 were deemed insignificant.

revised cardiac risk index ($P = 0.000$; odds ratio = 5.143), RV FAC (%) less than or equal to 35.6 ($P = 0.001$; odds ratio = 3.886), MR up to moderate ($P = 0.037$; odds ratio = 3.618), serum creatinine (mg/dl) greater than 1.4 ($P = 0.001$; odds ratio = 3.547), LAVI greater than 22 ($P = 0.014$; odds ratio = 3.009), serum urea (mg/dl) greater than 34 ($P = 0.004$; odds ratio = 2.932), and presence of preoperative AF ($P = 0.049$; odds ratio = 2.358) (Table 6).

Multivariate logistic regression analysis of PCC-related factors shows that the significant risk factors for PCCs are LVEF (%) less than or equal to 56 ($P = 0.039$; odds ratio = 14.896), TV E/A less than or equal to 1.18 ($P = 0.017$; odds ratio = 104.600), and Tie index greater than 0.47($P = 0.001$; odds ratio = 110.167) (Table 7).

4. Discussion

The results of this study show that in patients receiving high-risk NCS, RV echocardiographic characteristics are important preoperative indicators of postoperative cardiovascular events. This illustrates whether evaluation of RV function by echocardiography should be added before high-risk NCS.

There were few studies that discussed the prevalence and predictors of cardiovascular complications following noncardiac surgeries in relation to the RV echocardiographic parameters.

This prospective cohort, observational analytical study included adult patients who underwent major or high-risk noncardiac surgeries at El-Sahel Teaching Hospital and Al-Azhar University Hospitals in Cairo during the period between October 2020 and June 2021.

This study included 200 patients who were all candidates for major or high-risk NCS. Patients were allocated preoperatively into one group and postoperatively into two groups according to presence of postoperative cardiac complications as follows:

(1) Group A: patients without postoperative cardiac complications.
(2) Group B: patients with postoperative cardiac complications.

In our study, the incidence of postoperative cardiac complications was 36 of 200 patients, representing 18%, which is relatively high. Bolat et al.[6] performed a retrospective analysis of 660 patients undergoing major noncardiac surgeries and found that 80 patients (12.1%) experienced PCCs. On the contrary, Liu et al.[14] had found that the incidence of PCCs in patients older than 80 years old with CAD undergoing NCS was 19.4%. The results of previous published studies had shown that the incidence of PCCs was variable with operation types; it was 20% in the case of vascular surgery, as reported by Semeili and Lotofu.[15] This rate was comparable to the 19.3–22.6% reported for open abdominal aorta surgery by Bertges et al.[16]

Cardiac death occurred in eight cases, representing 4% of the study patients. This result is comparable to the results found by Liu et al.[14] and Chowdhury et al.[17] On the contrary, cardiac death rate was 2.7%, and our result was slightly greater than a study done by Bolat *et al.*[6] which found that cardiac death rate was 1.5%. In their study, they excluded the emergent operations, so the mortality was less than our study. On the contrary, our cardiac death rate was much lower than the results of Semeili and Lotoff[15] and Karam *et al.*[18] where cardiac death rates were 14 and 12%, respectively; however, their surgeries carry much high risk than our study, as they included high-risk vascular surgeries only.

Table 7. Multivariate analysis for categorical risk factors of PCCs among the patients with PCCs.

	B	SE	Wald	*P* value	Odds ratio (OR)	95% CI for OR	
						Lower	Upper
LVEF (%) ≤56	2.701	1.306	4.28	**0.039**	14.896	1.153	192.492
MV E/A ≤1.3	1.513	1.111	1.855	0.173	4.539	0.515	40.024
MV E/e′ >8.32	1.881	1.355	1.926	0.165	6.559	0.46	93.44
LAVI >22	2.944	1.797	2.685	0.101	18.993	0.561	642.441
RV FAC (%) ≤35	2.504	1.394	3.228	0.072	12.234	0.797	187.895
TAPSE ≤1.8	2.377	1.302	3.333	0.068	10.770	0.839	138.185
TV E/A ≤1.18	4.650	1.941	5.737	**0.017**	104.600	2.328	4700.316
Tie index >0.47	4.702	1.464	10.321	**0.001**	110.167	6.255	1940.34

CI, confidence interval; HbA1C, glycated hemoglobin; PCC, perioperative cardiovascular complication; RV FAC, right ventricular fractional area change.
P values lower than 0.05 were deemed significant.
P values lower than 0.001 were deemed highly significant.
P values greater than 0.05 were deemed insignificant.

Regarding demographic data and risk factors, our study showed insignificant results between the two groups concerning either age or sex. This result is comparable to Grant et al.[19] and Awad et al.[20]; however, it was against the results presented by Bolat and colleagues and Chowdhury and colleagues, which showed significant result according to age.[1,6] In our study, the mean age was less than their result by about 10 years, which means our patients are younger, and therefore, our result was insignificant.

Our insignificant results regarding sex distribution are comparable to the results of the previous two studies. Moreover, we did not find significant results between the two groups for the baseline criteria and past medical history, except for the presence of preoperative AF, which is comparable to the other literature studies. However, Bolat[6] found significant results for DM and heart failure, and also, Liu et al.[14] found significant results for preoperative ischemic heart disease (IHD) and peripheral vascular disease (PVD).

In this study, the predictors for PCCs were obtained in both study groups by multiple regression analysis for all preoperative variables to obtain the different predictors of PCCs. All numerical variables were assessed through ROC analysis to obtain the cutoff value before obtaining their odds ratio. All variables with odds ratio greater than 1 are considered risk factors, whereas those with odds ratio greater than 1 and significant P value less than 0.05 are considered significant predictors.

Our univariate analysis shows significant results for presence of preoperative AF ($P = 0.049$; odds ratio = 2.358). This result is comparable to the results found by Bolat.[6] On the contrary, our result was against Liu *et al.*[14] which showed insignificant result. HbA1C greater than 7.7 showed significant result in our study ($P = 0.000$; odds ratio = 7.042). The data presented by Laura et al.[21] showed that an increase in HbA1c had a significantly higher risk of postoperative myocardial infarction. Additionally, we discovered serum creatinine (mg/dl) greater than 1.4 ($P = 0.001$; odds ratio = 3.547) and serum urea (mg/dl) greater than 34 ($P = 0.004$; odds ratio = 2.932) as significant risk factors for PCCs. This result is similar to the results found by Chang et al.[3] and Liu *et al.*[14] and also Chowdhury et al.[17] found that end-stage renal disease was an independent risk factor for PCCs.

Revised cardiac risk index ($P = 0.000$; odds ratio = 5.143) was found to be a significant predictor for PCCs. This was also found by Bolat[6] and Semeili and Lotofu.[15] In general surgery, revised cardiac risk index (RCRI) is thought to be moderately accurate at differentiating between patients who are at high risk or low risk for perioperative cardiac events. However, in the subgroup of patients having vascular surgery, its efficacy was deemed to be poor.

We also found LVESDV (ml^3) greater than 35.6 ($P = 0.000$; odds ratio = 8.898) was considered a risk factor with significant result. This result was against Chang *et al.*[3] Bolat,[6] and Chowdhury et al.[17] Our result is comparable to Awad *et al.*[20] which found significant result. Moreover, we found that LVEF (%) less than 56 ($P = 0.000$; odds ratio = 15.222) was a significant predictor for PCCs. This is similar to the results found by Bolat *et al.*[6] Liu *et al.*[14] and Chowdhury et al.[17] and also Awad et al.[20] found significant results but with LVEF (%) less than 40. On the contrary, Jun et al.[22] found no significant result.

Presence of MR ($P = 0.037$; odds ratio = 3.618) was considered to be a significant risk factor. This result was similar to Chang *et al.*[3] Fleisher *et al.*[23] and Bajaj et al.[24] but was against the results found by Bolat[6] and Chowdhury et al.[17]

LV diastolic dysfunction was an important risk factor for serious major cardiovascular events after noncardiac surgeries, with MV E/A less than 1.3 ($P = 0.000$; odds ratio = 18.429) and MV E/e′ greater than 8.32 ($P = 0.002$; odds ratio = 5.388). These results are comparable to the results found by Bolat[6] and Chowdhury *et al.*[17] and also Chang et al.[3] and Jun et al.[22] found significant result according to MV E/e. On the contrary, Awad et al.[20] found no significant result for MV E/A and MV E/e′, and also Jun et al.[22] found no significant for MV E/A.

In our study, LAVI greater than 22 ($P = 0.014$; odds ratio = 3.009) was considered a significant predictor for PCCs. This result is similar to the results found by Chowdhury et al.[17] and Awad et al.[20] but was against the results found by Chang et al.[3] and Bolat et al.[6]

Regarding the RV echocardiographic parameters, our study results were significant for RV FAC (%) less than 35.6 ($P = 0.001$; odds ratio = 3.886). This result goes along with the results found by two studies of Grant et al.[19] and Awad et al.[20] but was against Bolat et al.[6] and Chowdhury et al.[17] Moreover, we had found TAPSE less than 1.8 ($P = 0.000$; odds ratio = 61.600) was a significant predictor, which agrees with Bolat *et al.*[6] Chowdhury *et al.*[17] and Awad et al.[20] Moreover, TV E/A less than 1.18 ($P = 0.000$; odds ratio = 63.600) showed significant results. These results are against Bolat *et al.*[6] Chowdhury *et al.*[17] and Awad et al.[20] The cause of this difference may be the size of the sample, which was much larger in Bolat and colleagues, or using very high cutoff point for significance in the study by Chowdhury and colleagues Moreover, we found

that Tie index greater than 0.47 ($P = 0.000$; odds ratio = 238.333) was significant, and it is comparable to the results of Bolat et al.[6] and Chowdhury et al.[17]

Our multivariate analysis revealed that LVEF (%) less than 56 ($P = 0.039$; odds ratio = 14.896) was considered as a significant factor, which goes along with the study done by Bolat et al.[6] Moreover, TV E/A less than 1.18 ($P = 0.017$; odds ratio = 104.600) and Tie index greater than 0.47 ($P = 0.001$; odds ratio = 110.167) were significant factors, which were against the study done by Bolat et al.[6]

4.1. Conclusion

This research shows that presurgical RV echocardiographic parameters are independent risk factors for PCCs in high-risk NCS patients. The existence of RV dysfunction before high-risk NCS as evaluated by TTE strongly anticipated PCCs in this preliminary analysis.

Conflict of interest

Authors declare that there is no conflict of interest, no financial issues to be declared.

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