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ORIGINAL RESEARCH

Outcome Comparison Between Insulin-Dependent and Non Insulin-Dependent Patients after Open Adult Cardiac Surgery

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ABSTRACT

Background: Insulin-dependent diabetic patients usually have poor glycemic control and higher risk of complications than non-insulin-dependent diabetic patients. However, the difference in clinical outcomes between these two groups of patients who underwent open cardiac surgery was not established. Therefore, this study compares the short-term outcome of insulin vs non-insulin-dependent diabetic patients after open cardiac surgery in a large-scale study.

Methods: The study design was a retrospective cohort. All adults who underwent open cardiac surgery between January 1st 2016-December 31st 2020 in 4 tertiary hospitals in Indonesia were included in the study. From a total of 4.931 samples included in the study, 3.753 patients were non-diabetic (Group I) and 1.178 were diabetic (Group II). Group II was divided into subgroup IIA (930 non-insulin-dependent) and subgroup IIB (248 insulin-dependent). The main outcome was in-hospital mortality of open cardiac surgery patients.

Result: In-hospital mortality between group I and II had no significant difference (6.8% vs 5.7%; p = 0.188), as well as IIA and IIB (5.6% vs 6%; p = 0.782). Multivariate analysis demonstrated that diabetes did not increase mortality of open cardiac surgery (OR 0.665; p = 0.021). In-hospital mortality of subgroup IIB was higher than subgroup IIA, but insulin therapy did not increase the risk of in-hospital mortality (OR 1.259; p = 0.464).

Conclusion: Both insulin-dependent and non-insulin-dependent diabetes mellitus were not the predictors of poor short-term outcomes for open adult cardiac surgery patients.

Keywords: diabetes mellitus; insulin; outcome; open cardiac surgery.

INTRODUCTION

Diabetes mellitus has been associated with a two-fold increase in the risk of cardiovascular disease. Furthermore, about 75% of mortality among coronary heart disease patients occurred in those with diabetes. Studies between the 1980s and 1990s suggested higher short-term and long-term mortality among diabetic patients who underwent open cardiac surgery versus nondiabetic patients. However, recent advancements in cardiac surgery resulted in a significantly improved outcome for diabetic patients. Studies about the effect of diabetes mellitus on the outcome of open cardiac surgery in general (not specific to coronary artery disease) are still limited. The purpose of this study was to assess the effect of diabetes mellitus and its treatments on short-term outcomes of post-open cardiac surgery patients.

METHODS

The ethical clearance requirement was waived for the current study due to its retrospective nature. We extracted the data from the medical records. This retrospective cohort study included patients who underwent open cardiac surgeries in 4 tertiary hospitals in Indonesia between Jan 1st, 2016, and Dec 1st, 2020. Inclusion criteria were > 17 years old of age during the procedure and open cardiac surgery patients. Exclusion criteria were incomplete medical records in the major outcomes. Patients were classified into 2 groups: group I (non-diabetic patients) and group II (diabetic patients). Diabetes mellitus was defined according to American Diabetes Association as (a) hemoglobin A1C ≥ 6,5%; (b) fasting blood glucose ≥ 126 mg/day; (c) classic symptom of hyperglycemia or hyperglycemic crisis, random plasma glucose level ≥ 200 mg/dL (11,1 mmol/L); (d) under pharmacologic treatment (oral antidiabetic drugs and/or insulin) or (e) established diabetes mellitus diagnosis. Patients treated with oral antidiabetic drugs were classified into subgroup IIA (non-insulin-dependent subgroup), and those treated with insulin were classified into subgroup IIB (insulin-dependent subgroup).

These variables were evaluated for the study: age, gender, chronic obstructive pulmonary disease, congenital heart disease (New York Heart Association [NYHA] functional class), ejection fraction, right ventricular dysfunction, diabetes mellitus, kidney failure, cerebral abnormalities, previous cardiac surgery, active endocarditis, arrhythmia, surgical urgency, systemic and pulmonary hypertension, left and right ventricular function, type of

surgery, poor mobility,
and *EuroSCORE* II scores. Outcome were in-hospital mortality, based on the discharge status in their medical records. In-hospital mortality was defined as post-operative mortality event that occured during hospital stay. ICU length of stay was number of days between ICU admission and ICU discharge, while hospital length of stay was number of days between surgery procedure and hospital discharge

As protocol, post-cardiac surgery patients were admitted to the intensive care unit (ICU). Afterward, some patients might require high care unit (HCU) admission while the rest went straight to the ward. During surgery procedures and ICU stays, patients received intravenous continuous infusions of regular insulin following the Society of Thoracic Surgeons' practice guidelines.

Statistical analysis

Descriptive statistic was performed to assess. Numerical variables were presented as mean and standard deviation. The normality of data distribution was analyzed by the Kolmogorov-Smirnov test. All numerical data were analyzed with an independent Student's t-test if they had normal distribution; otherwise Mann-Whitney-U test was used to evaluate the difference between groups. Categorical variables were analyzed using the Chi-square test.

Variables with potential association with patient mortality (univariate predictor) were evaluated using Fisher's exact test. Predictors with p-value < 0.25 were included in multivariable logistic regression to identify independent predictors of mortality. A P-value < 0.05 was considered statistically significant. All statistical analysis was performed using SPSS version 15.

RESULT

Overall patients demographic

During the 5 years, 4.985 patients had open cardiac surgery. Of these, 45 patients were excluded due to missing crucial data in their medical records. The final sample consisted of 4.931 patients. A total of 3.753 patients were non-diabetic (Group I) and 1.178 patients were diabetic (Group II). In the latter group, 930 patients were treated with oral antidiabetic drugs (subgroup IIA), and 248 were treated with insulin (subgroup IIB). Compared to non-diabetic drugs, diabetic groups were typically older, with male predominance, higher mean *EuroSCORE* II, higher prevalence of systemic hypertension, lower pulmonary hypertension, and lower ejection fraction (Table 1)

Table 1. Overall demographic data

No	Variable	Group I: Non-DM (n = 3753)	Group II: DM (n = 1178)	P-value
1	Age (years)	48.04 (13.728)	58.17 (8.196)	0.000*
2	Female	1,562 (41.6%)	258 (21.9%)	0.000*
3	NYHA functional class III-IV	1,293 (34.4%)	383 (32.5%)	0.216*
4	Ejection fraction (%)	59.26 (13.098)	55.23 (14.228)	0.000*
5	EuroSCOR*E* II	3,085 (3.472)	4.18 (4.837)	0.000*
6	Hypertension	1,240 (33%)	787 (66.8%)	0.000*
7	COPD	58 (1.5%)	34 (2.9%)	0.003*
8	Renal failure	191 (5.1%)	176 (14.9%)	0.000*
9	Cerebrovascular events	232 (6.2%)	151 (12.8%)	0.000*
10	Pulmonary hypertension	1,210 (32.3%)	122 (10.3%)	0.000*
11	Arrhythmia	863 (23%)	117 (9.9%)	0.000*
12	Previous cardiac surgery	78 (2.1%)	18 (1.5%)	0.231*
13	CABG procedure	1,181 (31.5%)	897 (76.1%)	0.000*
14	Right ventricular dysfunction	401 (10.7%)	80 (6.8%)	0.000*
15	Emergency	182(4.8%)	90 (7.6%)	0.000*
16	Active endocarditis	108 (2.9%)	8 (0.7%)	0.000*
17	Poor mobility	155 (4.1%)	61 (5.2%)	0.127*

*p < 0.25

DM: Diabetes Mellitus, NYHA: New York Heart Association, COPD: Chronic Obstructive Pulmonary Disease, CABG: Coronary Artery Bypass Graft

Demographic data of diabetic patients

Compared to non-insulin-dependent diabetic patients, insulin-dependent diabetics were younger, predominantly male, had lower ejection fractions, and had less previous cardiac surgery. Group II also had higher rates of renal failure, cerebrovascular events, active endocarditis, and higher proportions of patients with CABG procedures. Most diabetic patients were not hyperglycemic during examination (Table 2).

Outcome evaluation

In-hospital mortality between group I and II was 6.8 % vs. 5.7% (p = 0.188), and between group IIa and IIb was 5.6% vs. 6% (p = 0.782). Postoperative intra-aortic balloon pump was higher in diabetic patients (2.7% vs. 4.9%, p = 0.000), but there was no difference between non-insulin vs. insulin-dependent diabetic subgroups (5.4% vs. 3.3%, p = 0.185). Prolonged ICU stay (>48 hours) was similar between groups (Table 3), while hospital length of stay was longer in non-diabetic patients (Table 4).

Multivariate analysis

Multivariable logistic regression was performed to identify significant predictors of the primary outcome (in-hospital mortality). Variables in multivariate analysis were derived from univariate analysis of perioperative variables (Table 1 and Table 3) with a p-value of < 0,25.

Table 2. Demographic data of diabetic patients

No	Variable	Group IIA: Non-insulin (n = 930)	Group IIB: Insulin (n = 248)	P-value
1	Age (years)	58.32 (8.145)	57.63 (8.362)	0.241*
2	Female	211 (22.7%)	47 (19%)	0.206*
3	NYHA functional class III-IV	314 (33.8%)	68 (27.4%)	0.058
4	Ejection fraction (%)	55.61 914.228)	53.83 (14.195)	0.081*
5	*EuroSCORE* II	4.21 (0.051)	4.08 (0.037)	0.701
6	Hypertension	624 (67.1%)	163 (65.7%)	0.684
7	COPD	27 (2.9%)	7 (2.8%)	0.946
8	Renal failure	133 (14.3%)	43 (17.3%)	0.233*
9	Cerebrovascular events	112 (12%)	39 (15.7%)	0.123*
10	Pulmonary hypertension	95 (10.2%)	27 (10.9%)	0.758
11	Arrhythmia	96 (10.3%)	21 (8.5%)	0.386
12	Previous cardiac surgery	12 (1.3%)	6 (2.4%)	0.198*
13	CABG procedure	695 (74,8%)	201 (81%)	0.065*
14	Right ventricular dysfunction	62 (6.7%)	17 (6.9%)	0.904
15	Emergency	69 (7.4%)	21 (8.5%)	0.581
16	Active endocarditis	8 (0.9%)	0 (0%)	0.143*
17	Poor mobility	52 (5.6%)	9 (3.6%)	0.215*
18	Hyperglycemia	83 (8.9%)	33 (13.3%)	0.097*

*p < 0,25

DM: Diabetes Mellitus, NYHA: New York Heart Association, COPD: Chronic Obstructive Pulmonary Disease, CABG: Coronary Artery Bypass Graft

Table 3. Short-term outcomes in overall

No	Outcome	Group I: Non-DM (n = 3753)	Group II: DM (n = 1178)	P-value
1	In-hospital mortality†	254 (6.8%)	67 (5.7%)	0.188
2	Postoperative IABP	99 (2.7%)	57 (4.9%)	0.000*
3	ICU length of stay > 48 hours	143 (3.8%)	36 (3.1%)	0.230*
4	Hospital length of stay	10.49 (14.117)	9.59 (10.728)	0.044

*p < 0,25

†Main outcome

DM: Diabetes Mellitus, IABP: Intra-aortic Balloon Pump, ICU: Intensive Care Unit

Diabetes mellitus and insulin therapy in diabetic patients were also included in the multivariable logistic regression to verify their effects on in-hospital mortality. Age, previous cardiac surgery, cerebrovascular events, active endocarditis, and postoperative IABP were significant predictors for in-hospital mortality ($p < 0.0001$), as well as CABG procedure renal failure, cerebrovascular events, poor mobility, active endocarditis, arrhythmia, and ejection fraction ($p < 0.05$).

Table 4. Short-term outcome of diabetic patients

No	Outcome	Group IIA: Non-insulin (n = 930)	Group IIB: Insulin (n = 248)	P-value
1	In-hospital mortality†	52 (5.6%)	15 (6%)	0.782
2	Postoperative IABP	49 (5.4%)	8 (3.3%)	0.185
3	ICU length of stay > 48 hours	28 (3%)	8 (3.2%)	0.855
4	Length of hospital stay	9.63 (11.673)	9.38 (6.016)	0.742

†Main outcome

IABP: Intra-aortic Balloon Pump, ICU: Intensive Care Unit

Table 5. Multivariate analysis of all patients

No	Variable	p	Exp (B)	95% Confidence Interval	
				Lower	Upper
1	Emergency	0.657	1.151	0.620	2.138
2	CABG procedure	0.001**	0.821	0.734	0.919
3	Gender	0.551	1.087	0.827	1.428
4	Age	0.000**	1.034	1.022	1.046
5	Previous cardiac surgery	0.000**	3.839	2.213	6.662
6	Renal failure	0.001**	1.848	1.266	2.696
7	Hypertension	0.048**	0.752	0.567	0.997
8	Cerebrovascular events	0.001**	1.922	1.323	2.792
9	COPD	0.435	0.702	0.289	1.705
10	Active endocarditis	0.016**	2.158	1.157	4.024
11	Arrhythmia	0.012**	1.446	1.084	1.928
12	Poor mobility	0.001**	2.777	1.495	5.157
13	Pulmonary hypertension	0.128	1.255	0.936	1.683
14	Ejection fraction	0.003**	0.986	0.978	0.995
15	Right ventricular dysfunction	0.013**	1.560	1.099	2.215
16	NYHA functional class III-IV	0.968	1.005	0.784	1.289
17	Postoperative IABP	0.000**	4.420	2.854	6.846
18	Diabetes mellitus	0.021**	0.665	0.470	0.941
19	Insulin therapy in diabetic patients	0.464	1.259	0.680	2.331

**$p < 0.05$

DM: Diabetes Mellitus, NYHA: New York Heart Association, COPD: Chronic Obstructive Pulmonary Disease, CABG: Coronary Artery Bypass Graft, IABP: Intra-aortic Balloon Pump

Diabetes mellitus did not increase the risk of in-hospital mortality (OR 0.665; p = 0.021). Insulin-dependent diabetic patients had higher in-hospital mortality; however, treatment with insulin was not associated with a higher risk of in-hospital mortality (OR 1.259; p = 0.464) (Table 5).

DISCUSSION

The rise of coronary artery disease in developing countries, such as Indonesia has changed the demographics of cardiac surgical patients. Previously dominated by valve surgeries for rheumatic heart disease, coronary artery bypass graft for coronary artery disease is now more common[1–3]. In the current study, isolated CABG was performed in 31.5% of non-diabetic patients and 71.6% of diabetic patients. The isolated CABG procedures comprised 41.68% of all cardiac surgery procedures performed.

The prevalence of diabetes mellitus worldwide, especially in developing countries is steadily increasing, due to lifestyle changes and quick eating habits. In contrast to developed countries, the radical lifestyle changes in developing countries were not followed by adequate care. As a consequence, diabetic patients in developing countries were prone to more complications due to the delay in diagnosis and management[4–6]. In our study, diabetic patients had more comorbidities compared to non-diabetic; including hypertension, chronic obstructive pulmonary disease, renal failure, cerebrovascular events, pulmonary hypertension, arrhythmia, and right ventricular dysfunction. Similar findings were reported by Chadli *et al.,* that the majority of diabetic patients had at least 1 complication and were unable to reach 3 main targets: normal blood glucose, normal blood pressure, and lipid control[7]. In our study, hypertension was found in 66.8% of diabetic patients and poor glycemic control in 9.8% of diabetic patients.

There are several explanations for the apparent association between diabetes mellitus and coronary heart disease. Diabetes mellitus is associated with vascular complications, that may cause microvascular lesions and aggravate atherosclerotic processes. Delayed diagnosis and treatment, as well as lack of education in diabetic patients and poor treatment adherence, further worsened the problem and increase the risk of coronary artery disease. Furthermore, diabetes and coronary heart disease had similar risk factors, such as unhealthy lifestyles. Therefore, patients with poor lifestyles were prone to both diseases[7,8].

The close relationship between diabetes and coronary artery diseases is associated with an increased prevalence of coronary artery bypass graft (CABG) surgeries in diabetic patients.

Blumenfeld *et al.* in Israel reported that in the last 2 decades, there was a progressive rise in CABG surgeries and 41-49% of patients undergoing CABG were diabetics. Furthermore, due to CABG's superiority to PCI, especially for patients with complex coronary artery lesions, CABG patients usually had more comorbidities and complex coronary artery lesions, such as left main stenosis or high SYNTAX score.[8] In our study, 1178 of 4931 (23.89%) cardiac surgery patients were diabetics.

Several studies have debated the outcome of open cardiac surgery in diabetic patients. However, studies in developing countries were scarce, as most studies were performed in developed countries with better equipment, advanced medical technology, better care, and highly skilled practitioners[8]. On the other hand, our study results reflected the real situation in developing countries as our multicenter study was performed in Indonesia, one of the developing countries. Our study suggested that although diabetic patients were older and had more comorbidities, both diabetic and non-diabetic patients had similar in-hospital mortality (6.8% dan 5.7%; p = 0.188).

There were supporting and opposing studies of our results. Toh *et al.* reported that in-hospital mortality of diabetic and non-diabetic patients after open cardiac surgery was 4.83% vs. 3.09%, respectively (p = 0.02).[9] Zalewska-Adamiec *et al.* investigated the association between diabetes and left main coronary artery disease and did not find significant differences in 30-day mortality between diabetic and non-diabetic patients with left main coronary artery disease (11,6% vs. 11,1%; p = 0.928).[10] A study by Ram *et al.* found that overall 30-day mortality rate was similar between DM and non-DM patients (4.2% vs 4%, respectively, p = 0.976). they suggested that DMA was not associated with short-term cardiovascular events after CABG[11]. However, another study by Musa *et al.* found significantly higher proportion of in-hospital mortality among diabetic patients (5.7%) comparred to non-diabetic patients (3.4%). On univariate logistic regression analysis, both non-insulin dependent DM and insulin-dependent DM were significant predictors of in-hospital mortality after CABG surgery[12].

In our study, we did not find differences in the mortality between insulin-dependent diabetic and non-

insulin-dependent patients after open cardiac surgery (5.6% vs.6%; p = 0.782). Li *et al.* reported a similar mortality rate after the CABG procedure in diabetic and nondiabetic patients who were treated with oral antidiabetic drugs (1,88% vs. 2,01%), but there was significantly higher mortality in patients under insulin treatment (3.08%).[13] In the current study, insulin-dependent diabetes mellitus was associated with lower ejection fractions and higher rates of renal failure, cerebrovascular events, and active endocarditis. The FREEDOM study found similar results. They reported more comorbidities (hypertension, congestive heart failure, cerebrovascular events, chronic renal failure) and longer diabetes duration in insulin-dependent diabetes mellitus than non-insulin-dependent diabetes mellitus[2].

In a study by Wang *et al.*, insulin-dependent diabetic patients required higher insulin concentration than normally secreted by healthy beta-pancreatic cells. Insulin injection also induced the release of proinflammatory mediators such as tumor necrosis factor-alpha (TNF-alpha) and interleukin 1 (IL-1). This inflammatory process exacerbated atherosclerosis, disrupted the balance of endothelial production and release, and dysregulated hemodynamic and cardiovascular function, causing essential hypertension and cardiovascular pathology leading to heart failure. Ingelson *et al.* reported that insulin may act as a myocardial growth factor. Experimental studies demonstrated that prolonged hyperinsulinemia caused denser myocardial mass and lower cardiac output. 2) Hyperinsulinemia affected sodium retention and volume expansion that may lead to decompensation in people with subclinical myocardial dysfunction. 3) Hyperinsulinemia triggered the sympathetic nervous system which was hypothesized as the leading factor of congestive heart failure. 4) Insulin resistance was associated with elevated pressor response to angiotensin II and showed an intensification of angiotensin II effect on cellular hypertrophy and collagen production in patients with hypertension, initiating myocardial hypertrophy and fibrosis, and the risk of subsequent congestive heart failure[14].

Regardless of the association between diabetes and mortality after open-heart surgery, our study agreed that diabetic patients were prone to a lower ejection fraction than non-diabetic ones. Marfella *et al.* suggested that diabetic

patients without significant cardiovascular manifestation may have poorer diastolic function than their matched controls. Additionally, 47% of diabetic patients who were normotensive and asymptomatic with good glycemic control had diastolic dysfunction. From a noninvasive evaluation of cardiac performance, diabetic patients without a history of heart failure had prolonged pre-ejection and shorter ejection periods, both of which were correlated with a diminution of left ventricular ejection fraction at rest and reduced systolic function. Insulin-dependent diabetic patients also had lower ejection fractions during exercise, indicating a decline in cardiac reserve[15].

Several hypotheses were proposed to explain the mechanisms underlying cardiomyopathy in diabetic patients, such as insulin resistance and hyperglycemia, oxidative stress, inflammatory components, inappropriate immune modulation, alteration of subcellular components, abnormalities in coronary microcirculation, and endothelial dysfunction (including apoptosis, fibrosis, inflammation, and lipid accumulation). Marfella *et al.* investigated these cardiac changes on echocardiography and found no significant alterations in the myocardium and systolic function were detected during the very early stage. However, as the disease progressed, echocardiography displayed diastolic dysfunction (early stage) and systolic dysfunction (advanced stage). These functional alterations were impeded by the gradual loss of myocytes, triggering collagen accumulation, cross-linking, myocardial fibrosis, hyaline arteriolar sclerosis, and microaneurysms. Disproportionate neurohormonal activation exacerbated this process, worsening systolic dysfunction in the advanced stage of diabetic cardiomyopathy[15].

Inadequate perioperative glycemic control was identified as a significant predictor of in-hospital mortality and major complications in some studies. Ujueta *et al.* stated that unstable perioperative blood glucose was associated with poor outcomes due to inflammatory stimulation, thrombocyte activity, and endothelial dysfunction.[16] Therefore, perioperative blood glucose control is crucial to safe and effective open cardiac surgery. Magaji *et al.* reported substantial benefits from maintaining perioperative blood glucose between 110-140 mg/dL by adopting a continuous insulin injection protocol to

maintain glucose levels and prevent hypoglycemia[15].

Study limitation

This was a retrospective study, thus a prospective study may show a more profound and reliable association between diabetes mellitus and its treatment on mortality of open cardiac surgery patients. Studies with longer-term outcomes may also required to elucidate the association.

CONCLUSION

Both insulin-dependent and non-insulin-dependent diabetes mellitus were not predictors of short-term outcomes in open adult cardiac surgery patients.

CONFLICT OF INTEREST

The Authors declare that have no conflict of interest.

REFERENCES

1. Mohr FW, Morice MC, Kappetein AP, Feldman TE, Ståhle E, Colombo A, et al. Coronary artery bypass graft surgery versus percutaneous coronary intervention in patients with three-vessel disease and left main coronary disease: 5-year follow-up of the randomised, clinical SYNTAX trial. The Lancet. 2013 Feb;381(9867):629–38.
2. Farkouh ME, Domanski M, Dangas GD, Godoy LC, Mack MJ, Siami FS, et al. Long-Term Survival Following Multivessel Revascularization in Patients With Diabetes: The FREEDOM Follow-On Study. J Am Coll Cardiol. 2019 Feb 19;73(6):629–38.
3. Grant SW, Kendall S, Goodwin AT, Cooper G, Trivedi U, Page R, et al. Trends and outcomes for cardiac surgery in the United Kingdom from 2002 to 2016. JTCVS Open. 2021 Sep;7:259–69.
4. Bos M, Agyemang C. Prevalence and complications of diabetes mellitus in Northern Africa, a systematic review. BMC Public Health. 2013 Apr 25;13:387.
5. Glovaci D, Fan W, Wong ND. Epidemiology of Diabetes Mellitus and Cardiovascular Disease. Curr Cardiol Rep. 2019 Apr 4;21(4):21.
6. Natarajan K, Narayanan A, Hemapriya R, Swetha S, Jayashree R, Ninan B. Impact of elevated glycosylated hemoglobin (HbA1c) on the outcome following coronary artery bypass graft surgery. J Cardiothorac Vasc Anesth. 2019 Sep;33:S158.
7. Chadli A, El Aziz S, El Ansari N, Ajdi F, Seqat M, Latrech H, et al. Management of diabetes in Morocco: results of the International Diabetes Management Practices Study (IDMPS) - wave 5. Ther Adv Endocrinol Metab. 2016

Jun;7(3):101–9.

8. Blumenfeld O, Na'amnih W, Shapira-Daniels A, Lotan C, Shohat T, Shapira OM. Trends in Coronary Revascularization and Ischemic Heart Disease-Related Mortality in Israel. J Am Heart Assoc. 2017 Feb 17;6(2).
9. Toh K, Dill-Russell P, Valencia O. Diabetes mellitus and morbidity and mortality risks after cardiac surgery. Crit Care. 2001 Dec 4;5(S6):4.
10. Zalewska-Adamiec M, Bachorzewska-Gajewska H, Malyszko J, Tomaszuk-Kazberuk A, Nowak K, Hirnle T, et al. Impact of diabetes on mortality and complications after coronary artery by-pass graft operation in patients with left main coronary artery disease. Adv Med Sci. 2014 Sep;59(2):250–5.
11. Ram E, Sternik L, Klempfner R, Iakobishvili Z, Fisman EZ, Tenenbaum A, et al. Type 2 diabetes mellitus increases the mortality risk after acute coronary syndrome treated with coronary artery bypass surgery. Cardiovasc Diabetol. 2020 Dec 13;19(1):86.
12. Musa AF, Cheong XP, Yap CG, Dillon J, Nordin R Bin. Does diabetes mellitus increase the mortality risk in coronary artery disease patients undergoing coronary artery bypass grafting surgery at the National Heart Institute of Kuala Lumpur? J Diabetes Metab Disord Control. 2018 Aug 16;5(4):141–3.
13. Li Z, Amsterdam EA, Young JN, Hoegh H, Armstrong EJ. Contemporary Outcomes of Coronary Artery Bypass Grafting Among Patients With Insulin-Treated and Non-Insulin-Treated Diabetes. Ann Thorac Surg. 2015 Dec;100(6):2262–9.
14. Munnee K, Bundhun PK, Quan H, Tang Z. Comparing the Clinical Outcomes Between Insulin-treated and Non-insulin-treated Patients With Type 2 Diabetes Mellitus After Coronary Artery Bypass Surgery. Medicine. 2016 Mar;95(10):e3006.
15. Marfella R, Sardu C, Mansueto G, Napoli C, Paolisso G. Evidence for human diabetic cardiomyopathy. Acta Diabetol. 2021 Aug;58(8):983–8.
16. Ujueta F, Weiss EN, Sedlis SP, Shah B. Glycemic Control in Coronary Revascularization. Curr Treat Options Cardiovasc Med. 2016 Feb;18(2):12.