მედიცინა / Medical Sciences

Diastolic Dysfunction in the Left Ventricle and Its Prediction Systems

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Objective. To evaluate the universal prognostic value of left ventricular diastolic dysfunction (LVDD) when added to various clinical risk scores (EuroSCORE II, STS, MAGGIC) in patients undergoing coronary artery bypass grafting (CABG).

Materials and Methods. The study included 178 patients with coronary artery disease who underwent elec-tive CABG. Clinical, echocardiographic, and functional parameters were analyzed, including the assessment of left ventricular diastolic function. EuroSCORE II, STS, and MAGGIC risk scores were calculated for all patients. The prognostic value of the models was assessed using ROC analysis (AUC), DeLong test, risk reclassification indices (NRI, IDI), and Decision Curve Analysis.

Results. Left ventricular diastolic dysfunction was an independent predictor of postoperative complications. The addition of LVDD to the EuroSCORE II, STS, and MAGGIC models significantly improved their discrimi-native ability ($\Delta AUC = 0.07–0.08$; $p < 0.05$ for all models). NRI and IDI indices demonstrated a statistically significant improvement in risk stratification across all models. Decision Curve Analysis showed increased clinical usefulness of the combined models across a wide range of risk thresholds.

Conclusion. LVDD is a universal functional risk modifier that improves the prognostic accuracy of various clinical models. Inclusion of left ventricular diastolic function assessment in preoperative risk stratification algo-rithms for CABG may significantly improve clinical decision-making.

Keywords: CABG, diastolic dysfunction, EuroSCORE II, STS, MAGGIC, prognosis, NRI, IDI.

INTRODUCTION

Instrumental assessment and risk scores

All patients underwent a comprehensive examination including medical history assessment, evaluation of comorbidities, laboratory tests, ECG, and Doppler echocardiography. Doppler echocardiography was performed with assessment of systolic and diastolic left ventricular function; diastolic function was assessed ac-cording to standard methodology.

To assess surgical risk and predict postoperative complications, EuroSCORE II, STS score, and MAG-GIC score were calculated for all patients.

The study was conducted in accordance with the principles of the Helsinki Declaration. All patients signed informed consent.

Statistical analysis

Data analysis was performed using R and SPSS software packages. The normality of distribution was assessed using the Shapiro–Wilk test. Quantitative data are presented as median and interquartile range (Me [Q1; Q3]), and qualitative data as absolute and relative values (n, %).

Independent groups were compared using the Mann–Whitney test for quantitative variables and the Pearson χ^2 test or Fisher's exact test for categorical var-iables. Differences were considered statistically signif-icant at $p < 0.05$.

To identify risk factors for postoperative compli-cations, logistic regression analysis was performed with univariate and multivariate analysis. Results are presented as odds ratio (OR) with 95% confidence in-terval (CI).

The prognostic performance of the models was evaluated using ROC analysis (AUC), and model com-parison was performed using the DeLong test. The ad-ditional prognostic value of left ventricular diastolic dysfunction was assessed using risk reclassification in-dices (NRI, IDI). The clinical usefulness of the models was analyzed using Decision Curve Analysis (net ben-efit).

RESULTS

Table 1.

Baseline characteristics of patients (Group 1 – without complications, Group 2 – with complications) **Parameter**	**Without complications (n=136)**	**With complications (n=42)**	**p**
Age, years	58 [52; 64]	61 [55; 67]	0.15
Sex, n (%)	103 (75.7)	36 (85.7)	0.18
BMI, kg/m²	26.9 [24.4; 29.8]	27.2 [25.0; 30.5]	0.78
LVEDD, mm	55 [50–60]	52 [48–56]	>0.05
LVESD, mm	40 [33–45]	35 [30–40]	>0.05
IVS, mm	9.5 [10–12]	10.0 [9–11]	>0.05
LV posterior wall, mm	10.0 [10–12]	10.5 [9–11]	>0.05
LVEF, %	52 [46; 60]	45 [40; 52.8]	0.004
Heart rate, bpm	74 [65; 83]	82 [71; 91]	0.008
Left atrial diameter, mm	39 [38; 43]	43.5 [40; 47]	<0.001
Creatinine, μmol/L	90 [76; 107]	97.5 [89.8; 114]	0.025
EuroSCORE II	0.016 [0.011; 0.027]	0.0317 [0.0143; 0.0671]	0.002
STS score	0.009 [0.0065; 0.013]	0.0158 [0.0105; 0.0397]	<0.001
MAGGIC score	22 [19; 25]	24 [21; 27]	0.03
LVDD, n (%)	51 (37.8)	28 (66.7)	0.001
Diabetes mellitus, n (%)	58 (42.6)	16 (38.1)	0.52
Previous myocardial infarction	35 (25.7)	11 (26.2)	0.97
COPD	22 (16.2)	5 (11.9)	0.63
Smoking	25 (18.4)	6 (14.3)	0.64
Left ventricular hypertrophy	80 (58.8)	27 (64.3)	0.46

As can be seen from the data presented in Table 1, there were no differences between the groups in age, sex, and body mass index. The groups also did not differ significantly in left ventricular size and wall thickness, in the number of previous myocardial infarctions, in the presence of chronic obstructive pulmonary dis-ease, diabetes mellitus, smoking status, or left ventric-ular hypertrophy (according to ECG data).

Statistically significant differences between the groups were found in left ventricular ejection fraction, left ventricular diastolic dysfunction, heart rate, left atrial diameter, and blood creatinine levels. All

three risk scores (EuroSCORE II, STS, and MAGGIC) showed statistically significant differences between the groups.
In Table 2, the baseline characteristics of patients are presented with the indication of the standard devia-tion (± SD). They confirm the data presented in Table 1.

Table 2.

Baseline characteristics of patients (Group 1 – without complications, Group 2 – with complications). Val-ues are presented as mean ± SD. Comparison was performed using Welch's two-tailed t-test. Parameter	**Without complications (n=136)**	**With complications (n=42)**	**p**
BMI, kg/m²	29.1 ± 3.9	28.9 ± 4.9	0.71
LVEDD, mm	55 ± 0.66	52 ± 0.78	>0.05
LVESD, mm	40 ± 0.87	35 ± 1.09	>0.05
IVS, mm	9.5 ± 0.13	10.0 ± 0.22	>0.05
LV posterior wall, mm	10.0 ± 0.13	10.5 ± 0.22	>0.05
LVEF, %	51.1 ± 9.8	45.2 ± 11.1	0.002
Left atrial diameter, mm	39.8 ± 5.5	44.7 ± 7.9	<0.001
Heart rate, bpm	75.1 ± 13.5	83.1 ± 15.1	0.004
Creatinine, μmol/L	92.1 ± 25.6	102.9 ± 29.9	0.021
EuroSCORE II	0.016 ± 0.009	0.032 ± 0.028	<0.001
STS score	0.0095 ± 0.007	0.016 ± 0.015	0.001
MAGGIC score	21.8 ± 4.6	24.2 ± 5.3	0.007

The addition of left ventricular diastolic dysfunc-tion led to a statistically significant increase in AUC in all models ($p < 0.05$), while the most pronounced in-crease was observed for the MAGGIC score ($\Delta AUC = 0.13$), whereas the STS + LVDD model demonstrated the most balanced improvement in discriminative ability.
Risk reclassification analysis (NRI, IDI) con-firmed a clinically significant improvement in patient risk stratification. Decision Curve Analysis showed an increase in net benefit of the combined models across a wide range of threshold probabilities.
No statistically significant differences were found between the individual clinical scores ($p > 0.05$). Simi-larly, comparison of the combined models also did not show statistically significant differences ($p > 0.05$).
* $p < 0.05$ — statistically significant difference (DeLong test)

DISCUSSION

In the present study, it was shown that left ventric-ular diastolic dysfunction (LVDD) is a significant inde-pendent predictor of postoperative complications in pa-tients undergoing coronary artery bypass grafting (CABG). The addition of LVDD to traditional prognos-tic models (EuroSCORE II, STS, and MAGGIC) was accompanied by an improvement in discriminative ability, risk reclassification, and clinical usefulness, which indicates its additional prognostic value.

The obtained results confirm the concept that LVDD reflects myocardial functional reserve and inte-grates the influence of multiple pathophysiological fac-tors, including age, arterial hypertension, ischemia, and metabolic disorders [2–11]. Unlike traditional risk scores, which are mainly based on demographic and clinical variables, LVDD represents a functional pa-rameter that directly characterizes the ability of the my-ocardium to adapt to hemodynamic stress. This is con-sistent with

modern concepts of heart failure with pre-served ejection fraction (HFpEF), where impaired diastolic function plays a key role in clinical outcomes [2,12].

Clinically, it is important that LVDD is often de-tected in patients with preserved or moderately reduced left ventricular ejection fraction, which reflects the phe-nomenon of a “hidden” decrease in myocardial reserve. Population studies have shown that diastolic dysfunc-tion is associated with the development of heart failure and increased mortality even in the presence of normal systolic function [1]. Under conditions of surgical intervention, accom-panied by fluctuations in preload and afterload, sys-temic inflammatory response, and activation of neuro-humoral mechanisms, it is the decrease in diastolic re-serve that may limit the adaptive capacity of the heart and contribute to the development of complications. Previous studies have shown that diastolic dysfunction is an independent predictor of adverse outcomes after cardiac surgery, including increased mortality, duration of mechanical ventilation, and length of hospital stay [4,16,17].

Of particular importance are the results of the analysis of prognostic models. Despite a moderate in-crease in the area under the ROC curve (AUC), the ad-dition of LVDD led to a significant improvement in risk reclassification, which was confirmed by positive NRI and IDI values (see Fig. 1). This emphasizes the limita-tions of using only AUC to assess the prognostic value of new markers and is consistent with modern recom-mendations for evaluating risk models, where particu-lar attention is paid to the ability of the model to cor-rectly reclassify patients between risk categories [3].

Decision Curve Analysis demonstrated that inclu-sion of LVDD provides a higher net benefit in a clini-cally significant range of threshold probabilities com-pared with the baseline models (see Fig. 1). This indi-cates that the use of LVDD can not only improve the statistical characteristics of the models but also im-prove the quality of clinical decision-making in the pre-operative period, which is consistent with modern ap-proaches to assessing the clinical usefulness of prog-nostic models [4,5].

Interestingly, the greatest relative increase in dis-criminative ability was observed for the MAGGIC model, whereas the STS + LVDD model demonstrated the most balanced characteristics. This may reflect dif-ferences in the initial structure of the models: in partic-ular, the STS model already includes a wide range of clinical variables, whereas the MAGGIC model was originally developed for a population of patients with chronic heart failure.

It is fundamentally important that none of the widely used prognostic scores, including EuroSCORE II, STS, and MAGGIC, include direct indicators of left ventricular diastolic function. The obtained data demonstrate that the inclusion of LVDD makes it pos-sible to fill this gap and add a new, independent layer of risk information that is not covered by traditional variables.

The practical significance of the results lies in the possibility of integrating the assessment of diastolic function into preoperative risk stratification algorithms. This may contribute to more accurate identification of high-risk patients, optimization of management strategies, and potentially reduce the incidence of complications.

Thus, LVDD is a universal functional risk modi-fier that increases the accuracy and clinical applicabil-ity of existing prognostic models in patients undergoing CABG.

The limitations of the study include a single-cen-ter design and a relatively limited sample size. In addi-tion, the assessment of diastolic function was based on standard echocardiographic parameters, which may be subject to interoperator variability. Further multicenter studies are required to validate the obtained results and to determine the optimal ways of integrating left ventricular diastolic dysfunction into clinical risk models.

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