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Original Article

Evaluation of left ventricular function in patients with heart failure after myocardial infarction by real-time three-dimensional transesophageal echocardiography

Yanling Miao, Xiaoning Kang

Department II of Ultrasound, Cangzhou Central Hospital, Cangzhou, China

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Abstract: Objective: To evaluate the left ventricular function in patients with heart failure (HF) after myocardial infarction (MI) by real-time three-dimensional transesophageal echocardiography (RT-3D-TEE) and explore its correlation with serum cTnI and H-FABP levels. Methods: The data of 60 HF patients after MI from March 2019 to January 2021 were analyzed retrospectively and included in the research group. According to cardiac function grades, they were assigned to group A (20 cases), group B (20 cases), and group C (20 cases). During the same period, 50 healthy patients were included in the control group. The left atrial diameter (LAD), interventricular septum thickness (IVST), left ventricular posterior wall thickness (LVPWT), left ventricular end-systolic volume (LVESV), left ventricular end-diastolic volume (LVEDV), left ventricular stroke volume (LVSV), and left ventricular ejection fraction (LVEF) of participants were recorded and compared in the four groups. The serum levels H-FABP and cTnI were tested by ELISA. Results: HF patients had poorer left heart structure and lower function and higher serum H-FABP and cTnI levels, as compared to the subjects in control group. Correlation analysis indicated that the cardiac function grade was positively correlated with LVEDV, LVESV, H-FABP, and cTnI, but negatively correlated with LVEF. The serum H-FABP and cTnI levels of HF patients were positively correlated with LVEDV and LVESV, but negatively correlated with LVEF. Logistic regression analysis revealed that cTnI and H-FABP were risk factors for HF, and LVEF was a protective factor for HF. Conclusion: Serum H-FABP and cTnI levels in HF patients are correlated with left ventricular function parameters, which presents a close relation to HF. RT-3D-TEE combined with the detection of serum H-FABP and cTnI yields important clinical significance for early diagnosis of HF.

Keywords: Real-time three-dimensional transesophageal echocardiography, myocardial infarction, heart failure, left ventricular function, cTnI, H-FABP

Introduction

Myocardial infarction (MI) refers to myocardial necrosis caused by coronary artery occlusion, insufficient blood supply, or continuous ischemia and hypoxia. Patients are usually accompanied with progressive electrocardiogram (ECG) change and increased serum myocardial enzyme activity, which may lead to serious complications and take a toll on patients' safety [1, 2]. As one of the major complications of MI, heart failure (HF) mainly refers to left heart failure, which invariably results in a somber prognosis and even death in MI patients [3]. In recent years, due to the aging of the population and the changes in living habits, the incidence of HF has been rising continuously, which poses a serious threat to the life and health of the elderly [4]. Therefore, evaluation of cardiac function, early detection of the changes in left heart function, and timely symptomatic treatment are the keys to the prevention and treatment of patients with HF after MI.

In recent years, clinical imaging plays a vital role in evaluating the grade and severity of cardiovascular diseases [5]. Real-time three-dimensional transesophageal echocardiography (RT-3D-TEE) is a breakthrough in the field of ultrasonic diagnosis, and its application in clinical cardiac function evaluation has gradually expanded in recent years [6]. This technique can display the lesion site and adjacent structure stereoscopically, clearly, and intuitively on the basis of observing the three-dimensional shape and spatial orientation of the heart and great vessels [7]. However, its application in assessing left ventricular function in patients with HF after MI remains one of the most pressing clinical issues to be addressed.

Cardiac troponin I (cTnI) exists specifically in myocardial cells and is considered as a specific marker protein of MI [8]. Heart-type fatty acid-binding protein (H-FABP) is a soluble protein. When myocardial cells suffer from ischemia and hypoxia, the level of H-FABP increases rapidly, and it can be released from the ventricle to plasma because of its small molecular weight. Therefore, the change of serum H-FABP level can reflect the degree of impaired cardiac function [9]. In recent years, the role of cTnI and H-FABP in the diagnosis of MI has also attracted much attention.

Based on this, we designed a controlled trial to test the left ventricular function of the subjects by RT-3D-TEE. Consequently, the application effect of echocardiography was compared and evaluated through the detection results, and the correlation between serum cTnI, H-FABP levels, and left ventricular function parameters was observed, to provide a more scientific basis for the prevention and treatment of patients with HF after MI.

Methods

Clinical data

The data of 60 patients with HF after MI from March 2019 to January 2021 were analyzed retrospectively, and they were included in the research group. According to cardiac function grade, they were assigned to group A (cardiac function grade II, 20 cases), group B (cardiac function grade III, 20 cases), and group C (cardiac function grade IV, 20 cases). During the same period, 50 healthy patients were selected as the control group.

Inclusion criteria: ① Patients included in the study met the diagnostic criteria for MI and HF by the World Health Orgnization (WHO) [10]; ② The patients were diagnosed with MI by coronary angiography; ③ The patients whose family members were informed of the study and signed an informed consent form.

Exclusion criteria: ① Patients with malignant tumors; ② Patients with incomplete case data; ③ Patients whose HF was not induced by MI; ④ Patients with severe liver and kidney dysfunction.

This research has been ratified by the Ethics Committee of Cangzhou Central Hospital (Approval no.: 2019-275-03). All sample collection and data investigation were carried out after having obtained the informed consent and signature of patients and their families, which was in line with the Declaration of Helsinki of the World Medical Association. Clinical trial registration: This study had been registered with the registration No. of ChiCTR2017109 (URL: http://www.chictr.org.cn/showproj.aspx?proj=2018XE057-3).

Instruments and methods

Transthoracic and transesophageal ultrasound devices included Philips EElite, S5-1 2.0-7.0 MHz, X7-2T2-7 MHz, QLab analysis software. The left ventricular systolic and diastolic functions were assessed by transthoracic echocardiography. After examination, the tissue Doppler mode was adopted at the apical four-chamber view, and TDI examination was conducted to obtain images of five consecutive cardiac cycles. Left ventricular ejection fraction (LVEF) and indexes reflecting left heart function were tested by single cardiac cycle RT-3D-TEE.

Outcome measures

(1) The left ventricular structural parameters of the participants were recorded and compared among the four groups, including left atrial diameter (LAD), interventricular septum thickness (IVST), and left ventricular posterior wall thickness (LVPWT).

(2) In the four groups, the left ventricular function parameters were recorded and compared, including left ventricular stroke volume (LVSV), left ventricular end-diastolic volume (LVEDV), left ventricular end-systolic volume (LVESV), LVEF, etc.

Detection of serum indexes

The levels of serum H-FABP and cTnI were detected. The fasting elbow vein peripheral blood (4 mL) was drawn in the early morning of the

Table 1. Baseline data

Factors	Research group n=60	Control group n=50	t/X^2	P
Gender			0.031	0.860
Male	35 (58.33)	30 (60.00)		
Female	25 (41.67)	20 (40.00)		
Age (years old)	65.96±4.33	66.03±5.38	0.076	0.940
BMI (kg/m^2)	23.11±1.14	23.12±1.16	0.0.45	0.964
Drinking history			0.001	0.972
Yes	31 (51.67)	26 (52.00)		
No	29 (48.33)	24 (48.00)		
Smoking history			0.020	0.888
Yes	26 (43.33)	21 (42.00)		
No	34 (56.67)	29 (58.00)		
Hypertension			-	-
Yes	25 (41.67)	-		
No	35 (58.33)	-		
Hyperlipoidemia		-	-	-
Yes	39 (65.00)	-		
No	21 (35.00)	-		
TG (mmol/L)	4.09±0.58	1.45±0.61	23.22	<0.001
TC (mmol/L)	2.24±0.58	3.71±1.15	8.67	<0.001

second day after admission and centrifuged at 3500 r/min for 10 min (an effective centrifugal radius of 10 cm). The serum was segregated and placed in a refrigerator at -80°C for testing. enzyme-linked immunosorbent assay (ELISA) was used to detect the levels of serum H-FABP (kit number: EPX010-12263-901, Invitrogen, United States) and cTnI (kit number: MA-1-20117, Invitrogen, United States). The specific operation was strictly in accordance with the kit specifications.

Statistical treatment

SPSS 27.0 was used for statistical analysis. The measurement data conforming to normal distribution were represented by mean ± standard deviation. One-way ANOVA was used for comparison among multiple groups. A t-test was used for comparison between the two groups. The correlation between echocardiographic parameters, serum H-FABP, cTnI levels and cardiac function grade was analyzed by the Spearman method. Multiple stepwise regression analysis was used to predict the evaluation factors of patients' cardiac function grade. The difference was statistically significant with P<0.05.

Results

Comparison of baseline data

There was no obvious difference in gender, age, BMI, and smoking history between the two groups (all P>0.05), indicating that the two groups were comparable. However, research group garnered superior triglyceride (TG) and total cholesterol (TC) outcome as compared to control group (**Table 1**).

Comparison of the left ventricular structural changes of subjects

Compared with the control group, LAD and IVST in patients with HF were remarkably higher (P<0.05). The highest levels of LAD and IVST of patients with HF were observed in group C, followed by group B, and then group A (P<0.05). The four groups displayed no significant disparity in LVPWT (P>0.05) (**Table 2**).

Comparison of the left ventricular function of subjects among four groups

In contrast to the control group, the group A, group B, and group C obtained higher levels of LVEDV and LVESV and lower levels of LVEF (P<0.05). Moreover, the LVEDV and LVESV of patients with HF presented the highest level in group C, followed by group B, and then group A. Similarly, group C obtained the lowest level of LVEF, followed by group B, and then group A (P<0.05) (**Figure 1**).

Serum H-FABP and cTnI levels of subjects in the four groups

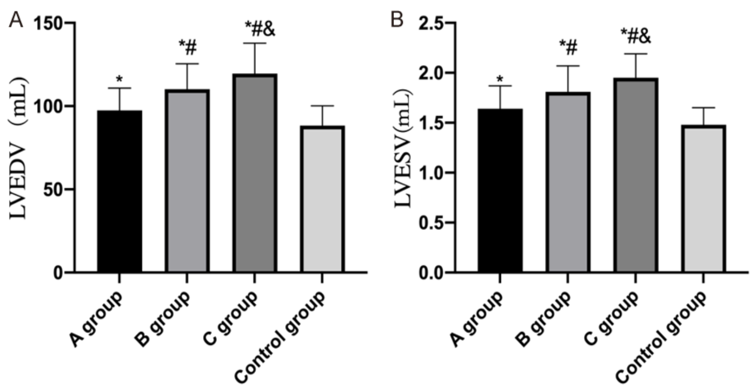
Notably higher levels of serum H-FABP and cTnI in patients with HF than those in control group were found (P<0.05). The highest levels of serum H-FABP and cTnI were witnessed in patients of group C, followed by group B, and then group A (P<0.05) (**Figure 2**).

Correlation analysis between left ventricular function parameters and cardiac function grade

The cardiac function grade was positively correlated with LVEDV and LVESV but negatively correlated with LVEF (**Table 3**).

Table 2. Comparison of the left ventricular structural changes of subjects among four groups

Indexes	Group A n=20	Group B n=20	Group C n=20	Control group n=50	F	P
LAD (d/mm)	30.57±4.16	32.06±4.21	33.17±4.24	28.39±4.11	7.905	<0.001
IVST (d/mm)	8.23±1.36	8.46±1.42	8.67±4.45	7.78±1.29	14.89	<0.001
LVPWT (d/mm)	7.85±1.11	8.13±1.14	8.26±1.19	7.75±1.06	1.284	0.284



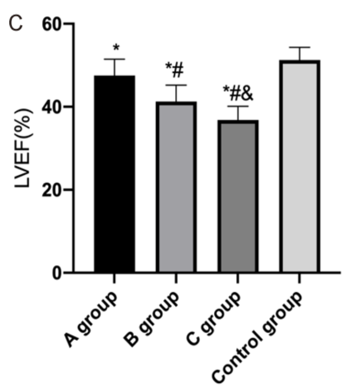


Figure 1. Comparison of the left ventricular function of subjects among four groups. A: Comparison of the LVEDV of subjects among four groups; B: Comparison of the LVESV of subjects among four groups; C: Comparison of the LVEF of subjects among four groups. *means the comparison with control group, groups # and &, P<0.05; #Means the comparison with &, P<0.05.

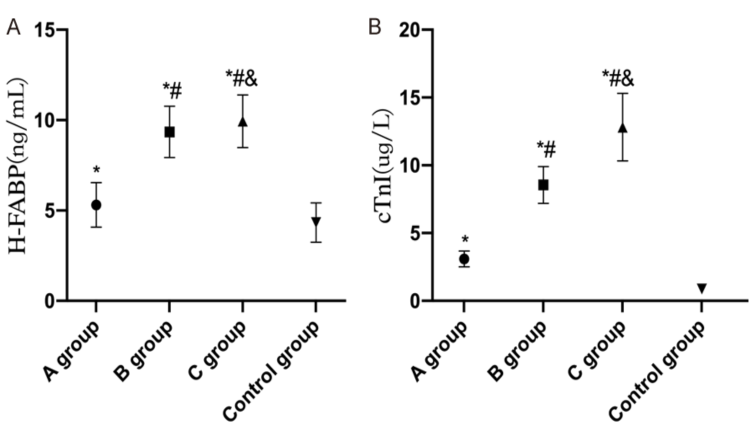


Figure 2. Serum H-FABP and cTnI levels of subjects in the four groups. A: Comparison of the serum H-FABP of subjects among four groups; B: Comparison of the serum cTnI levels of subjects among four groups. *Means the comparison with control group, groups # and &, P<0.05; #Means the comparison with &, P<0.05.

Correlation analysis between serum H-FABP, cTnI levels, and cardiac function grade

Spearman correlation analysis revealed that the levels of serum H-FABP and cTnI were positively correlated with cardiac function grade (**Table 4**).

Correlation analysis between left ventricular function parameters and serum H-FABP and cTnI levels in patients with HF

Pearson correlation analysis revealed that the serum H-FABP and cTnI levels of patients with HF were positively correlated with LVEDV and LVESV, but negatively correlated with LVEF (**Table 5**).

Multivariate analysis of influencing HF

H-FABP, cTnI, LVEDV, LVESV, and LVEF were taken as independent variables for Logistic regression analysis. The results revealed that cTnI and H-FABP were risk factors for HF, and LVEF was a protective factor for HF (**Table 6**).

Discussion

HF, one of the serious complications for patients with MI, is also a complex clinical syndrome of almost all patients with cardiovascular diseases in the terminal stage [10, 11]. Currently, the incidence of HF is showing a trend of elevation.

Table 3. Correlation analysis between left ventricular function parameters and cardiac function grade

		LVEDV	LVESV	LVEF
Cardiac function grade	r	0.589	0.492	-0.493
	P	<0.001	<0.001	<0.001

Table 4. Correlation analysis between serum H-FABP, cTnI levels, and cardiac function grade

		H-FABP	cTnI
Cardiac function grade	r	0.523	0.572
	P	<0.001	<0.001

Table 5. Correlation analysis between left ventricular function parameters and serum H-FABP and cTnI levels in patients with HF

		LVEDV	LVESV	LVEF
H-FABP	r	0.539	0.492	-0.623
	P	0.008	0.012	<0.001
cTnI	r	0.546	0.527	-0.533
	P	0.005	0.003	0.001

With the aging of the population, HF has become one of the main factors threatening the life and health of the elderly [12]. The main mechanism of HF triggered by MI stems from the impaired diastolic and systolic functions in the infarct site after the myocardial necrosis caused by continuous ischemia and hypoxia of the coronary artery. The continuous ischemia and hypoxia impede the systole and diastole of the whole heart, which gives rise to cardiovascular blockage, thereby resulting in the decline of heart function and eventually HF [13]. Clinically, HF is also the major cause of death in patients with MI [14]. Therefore, the key measures for the prevention and treatment of patients with HF after MI are to evaluate the heart function, understand the changes in left heart function, and carry out timely symptomatic treatment.

Traditional B-ultrasound imaging can only provide two-dimensional images, which relies more on the experience of clinicians in reconstructing the two-dimensional structure of organs abstractly; Consequently, the accuracy of diagnosis is unstable to a certain extent [15]. As one of the ECGs in the development of new technology in recent years, RT-3D-TEE makes up for the shortcomings of two-dimensional TEE (such as the limited angle). It can view images from any angle and any plane, and dynamically observe the volume changes and systolic and diastolic activities of the left heart, to provide a corresponding scientific basis for the clinical treatment and diagnosis, thereby preventing missed diagnosis and reducing unnecessary surgical treatment [16, 17]. To date, RT-3D-TEE has been widely used in clinical practice and its technology has become more and more sophisticated, which lays a foundation for expanding its application in various diseases. RT-3D-TEE is used to detect the left ventricular function of patients. Among the related parameters of heart function, LVEF and LVESV can reflect the left ventricular systolic function of patients with HF, and LVEDV can better evaluate the left ventricular diastolic function [18]. Our research revealed that compared with the control group, the LVESV and LVEDV in patients with HF were markedly increased, while LVEF was drastically declined, and there was an obvious correlation between LVEF and cardiac function grade. LVESV, LVEDV, and LVEF may be regarded as essential indexes for predicting cardiac function grade. Previous studies [19] have revealed the working mechanism of RT-3D-TEE, which mainly collects initial 3D data by obtaining the echo features of many single points in the tissue volume. Other studies [20, 21] have pointed out that compared with 2D TEE, RT-3D TEE can provide additional qualitative information about mitochondrial valve equipment. With higher sensitivity in detecting valve perforation, RT-3D TEE can better describe its size and location. However, as imaging diagnosis may be affected by ventricular coordination, the actual cardiac function requires related indicators for a better analysis.

As a kind of heart-specific fatty acid-binding protein, H-FABP exists widely in myocardial cells and is rapidly released into the blood after MI [22]. In addition, the increase of H-FABP level will damage the vascular endothelium, which will further aggravate the disease. As a result, it has been considered as one of the key indices for the evaluation of MI [23, 24]. cTnI is a kind of myocardial-specific structural protein, which mainly exists in the cytoplasm of myocardial cells in complex form and participates in

Table 6. Multivariate analysis of influencing factors for HF

	Regression coefficient	Standard error	Wald X^2 value	OR	95% CI	P
H-FABP	1.398	0.631	4.933	4.018	2.261~7.162	0.005
cTnI	1.823	0.871	4.631	6.239	4.368~9.461	0.002
LVEDV	0.089	0.108	0.679	1.078	0.139~8.224	0.302
LVESV	0.377	0.311	1.442	1.452	0.321~6.533	0.378
LVEF	-1.129	0.631	3.228	0.318	0.122~0.829	0.009

myocardial contraction together with myocardial calcium ions. When myocardial cells are damaged, cTnI will be released into the serum accordingly. Therefore, the level of cTnI in the serum can respond to myocardial cell damage sensitively [25, 26]. H-FABP and cTnI, as special serum markers of MI, have been widely adopted in the diagnosis of AMI [27]. Moreover, it has also been confirmed that cTnI and h-FABP exert certain effects on the diagnostic rate of HF [28]. This research revealed that serum cTnI and H-FABP of patients with HF were significantly higher than those of the subjects in control group, and the two indexes were positively correlated with cardiac function grade. Furthermore, prior study [29] detected the serum H-FABP and cTnI in asphyxial newborns and found that the serum H-FABP and CTNI levels of asphyxial children with MI were remarkably higher than those of newborns without MI, which further verified the close relationship between H-FABP, cTnI and MI. It was also found that there was a better correlation between the related parameters of left heart function and the levels of serum H-FABP and cTnI, which suggested that the combined analysis of RT-3D-TEE and serological indicators can be employed as the reference indicators of HF. The results of logistic regression analysis demonstrated that H-FABP and cTnI were risk factors for HF, and LVEF was a protective factor for HF. It suggested that the changes of serum H-FABP, cTnI, and left ventricular function parameters should be closely monitored clinically, which is of great significance to reduce the mortality of patients with HF after MI.

Conclusion

To sum up, the levels of serum H-FABP and cTnI in patients with HF are correlated with left ventricular function parameters, and they are closely related to HF. The combined detection of RT-3D-TEE and serum H-FABP and cTnI has important clinical significance for the early diagnosis of HF. However, the study is limited by the small sample size and few clinical-related indicators. A larger sample size and more related indices will be included in the clinical evaluation of cardiac function grade, to evaluate the cardiac function of HF patients with higher accuracy and objectiveness.

Disclosure of conflict of interest

None.

Address correspondence to: Xiaoning Kang, Department II of Ultrasound, Cangzhou Central Hospital, West 16 Xinhua Road, Yunhe District, Cangzhou, China. Tel: +86-15350771157; E-mail: kangxiaoning87@163.com

References

[1] Pollard TJ. The acute myocardial infarction. Prim Care 2000; 27: 631-649.

[2] Xiong P, Xue Y, Zhang J, Liu M, Du H, Zhang H, Hou Z, Wang H and Liu X. Localization of myocardial infarction with multi-lead ECG based on DenseNet. Comput Methods Programs Biomed 2021; 203: 106024.

[3] Sia CH, Ko J, Zheng H, Ho AF, Foo D, Foo LL, Lim PZ, Liew BW, Chai P, Yeo TC, Tan HC, Chua T, Chan MY, Tan JWC, Bulluck H and Hausenloy DJ. Association between smoking status and outcomes in myocardial infarction patients undergoing percutaneous coronary intervention. Sci Rep 2021; 11: 6466.

[4] Kim W, Kim JS, Rha SW, Choi BG, Jang WY, Kang DO, Park Y, Choi JY, Roh SY, Na JO, Choi CU, Kim EJ, Park CG, Seo HS, Choi SY, Byun JK, Cha J, Oh DJ and Jeong MH; other Korea Acute Myocardial Infarction Registry (KAMIR) investigators. Cilostazol-based triple versus potent P2Y12 inhibitor-based dual antiplatelet therapy in patients with acute myocardial infarction undergoing percutaneous coronary intervention. Heart Vessels 2020; 35: 1181-1192.

[5] Edqvist J, Rawshani A, Adiels M, Bjorck L, Lind M, Svensson AM, Gudbjornsdottir S, Sattar N

and Rosengren A. Contrasting associations of body mass index and hemoglobin A1c on the excess risk of acute myocardial infarction and heart failure in type 2 diabetes mellitus. J Am Heart Assoc 2019; 8: e013871.
[6] Kovalova S and Necas J. RT-3D TEE: characteristics of mitral annulus using mitral valve quantification (MVQ) program. Echocardiography 2011; 28: 461-467.
[7] Al-Kassou B, Tzikas A, Stock F, Neikes F, Volz A and Omran H. A comparison of two-dimensional and real-time 3D transoesophageal echocardiography and angiography for assessing the left atrial appendage anatomy for sizing a left atrial appendage occlusion system: impact of volume loading. EuroIntervention 2017; 12: 2083-2091.
[8] Chapman AR, Hesse K, Andrews J, Lee KK, Anand A, Shah ASV, Sandeman D, Ferry AV, Jameson J, Piya S, Stewart S, Marshall L, Strachan FE, Gray A, Newby DE and Mills NL. High-sensitivity cardiac troponin I and clinical risk scores in patients with suspected acute coronary syndrome. Circulation 2018; 138: 1654-1665.
[9] Van Hise CB, Greenslade JH, Parsonage W, Than M, Young J and Cullen L. External validation of heart-type fatty acid binding protein, high-sensitivity cardiac troponin, and electrocardiography as rule-out for acute myocardial infarction. Clin Biochem 2018; 52: 161-163.
[10] Ulrich R, Pischon T, Robra BP, Freier C, Heintze C and Herrmann WJ. Health care utilisation and medication one year after myocardial infarction in Germany-a claims data analysis. Int J Cardiol 2020; 300: 20-26.
[11] Sandoval Y, Smith SW, Sexter A, Schulz K and Apple FS. Use of objective evidence of myocardial ischemia to facilitate the diagnostic and prognostic distinction between type 2 myocardial infarction and myocardial injury. Eur Heart J Acute Cardiovasc Care 2020; 9: 62-69.
[12] Beggs SAS, Rorth R, Gardner RS and McMurray JJV. Anticoagulation therapy in heart failure and sinus rhythm: a systematic review and meta-analysis. Heart 2019; 105: 1325-1334.
[13] Y Reddy V, Petrů J, Málek F, Stylos L, Goedeke S and Neužil P. Novel neuromodulation approach to improve left ventricular contractility in heart failure: a first-in-human proof-of-concept study. Circ Arrhythm Electrophysiol 2020; 13: e008407.
[14] Christiansen MN, Kober L, Torp-Pedersen C, Smith JG, Gustafsson F, Vejlstrup NG, Damm P, Johansen M, Andersson C and Ersboll AS. Prevalence of heart failure and other risk factors among first-degree relatives of women with peripartum cardiomyopathy. Heart 2019; 105: 1057-1062.
[15] Mukherjee C, Tschernich H, Kaisers UX, Eibel S, Seeburger J and Ender J. Real-time three-dimensional echocardiographic assessment of mitral valve: is it really superior to 2D trans-esophageal echocardiography? Ann Card Anaesth 2011; 14: 91-96.
[16] Gadhinglajkar S and Sreedhar R. Surgery for ruptured sinus of valsalva aneurysm into right ventricular outflow tract: role of intraoperative 2D and real time 3D transesophageal echocardiography. Echocardiography 2010; 27: E65-69.
[17] Tsai SK, Wei J, Hsiung MC, Ou CH, Chang CY, Chuang YC, Lee KC and Chou YP. The additional value of live/real-time three-dimensional transesophageal echocardiography over two-dimensional transesophageal echocardiography for assessing mitral regurgtation with eccentric jets. J Chin Med Assoc 2013; 76: 372-377.
[18] Zhao XX and Yuan WF. The 4D B-spline method of calculating left ventricular functional parameters of cardiac MRI to evaluate myocardial injury of the apical segment in patients with myocarditis: a case-controlled observational study. Quant Imaging Med Surg 2020; 10: 2133-2143.
[19] Yildiz R, Ok M, Ider M, Aydogdu U and Erturk A. Heart-type fatty acid-binding protein (H-FABP), pentraxin-3 (PTX-3) and thrombomodulin in bovine traumatic pericarditis. Acta Vet Hung 2019; 67: 505-516.
[20] Sugeng L, Shernan SK, Salgo IS, Weinert L, Shook D, Raman J, Jeevanandam V, Dupont F, Settlemier S, Savord B, Fox J, Mor-Avi V and Lang RM. Live 3-dimensional transesophageal echocardiography initial experience using the fully-sampled matrix array probe. J Am Coll Cardiol 2008; 52: 446-449.
[21] Salustri A, Becker AE, van Herwerden L, Vletter WB, Ten Cate FJ and Roelandt JR. Three-dimensional echocardiography of normal and pathologic mitral valve: a comparison with two-dimensional transesophageal echocardiography. J Am Coll Cardiol 1996; 27: 1502-1510.
[22] Thompson KA, Shiota T, Tolstrup K, Gurudevan SV and Siegel RJ. Utility of three-dimensional transesophageal echocardiography in the diagnosis of valvular perforations. Am J Cardiol 2011; 107: 100-102
[23] Bivona G, Agnello L, Bellia C, Lo Sasso B and Ciaccio M. Diagnostic and prognostic value of H-FABP in acute coronary syndrome: still evidence to bring. Clin Biochem 2018; 58: 1-4.
[24] Clerico A, Zaninotto M, Padoan A, Ndreu R, Musetti V, Masotti S, Prontera C, Passino C, Carlo Zucchelli G, Plebani M and Migliardi M. Harmonization of two hs-cTnI methods based on recalibration of measured quality control and

clinical samples. Clin Chim Acta 2020; 510: 150-156.
[25] Zhang Y, Luo Y, Nijiatijiang G, Balati K, Tuerdi Y and Liu L. Correlations of changes in brain natriuretic peptide (BNP) and cardiac troponin I (cTnI) with levels of C-reactive protein (CRP) and TNF-alpha in pediatric patients with sepsis. Med Sci Monit 2019; 25: 2561-2566.
[26] Peng C, Luo X, Xing Q, Sun H and Huang X. Suberoylanilide hydroxamic acid restores estrogen reduced-cTnI expression in neonatal hearts of Mice. J Cell Biochem 2016; 117: 2377-2384.
[27] Collinson P, Gaze D and Goodacre S. Comparison of contemporary troponin assays with the novel biomarkers, heart fatty acid binding protein and copeptin, for the early confirmation or exclusion of myocardial infarction in patients presenting to the emergency department with chest pain. Heart 2014; 100: 140-145.
[28] Bjurman C, Petzold M, Venge P, Farbemo J, Fu ML and Hammarsten O. High-sensitive cardiac troponin, NT-proBNP, hFABP and copeptin levels in relation to glomerular filtration rates and a medical record of cardiovascular disease. Clin Biochem 2015; 48: 302-307.
[29] Zhou FJ, Zhou CY, Tian YJ, Xiao AJ, Li PL, Wang YH and Jia JW. Diagnostic value of analysis of H-FABP, NT-proBNP, and cTnI in heart function in children with congenital heart disease and pneumonia. Eur Rev Med Pharmacol Sci 2014; 18: 1513-1516.