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ORIGINAL

EVALUATING DIASTOLIC FUNCTION IN FOOTBALL PLAYERS WITH MYOCARDIAL INFARCTION AND PRESERVED EJECTION FRACTION HEART FAILURE: A CLINICAL STUDY USING ECHOCARDIOGRAPHY

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ABSTRACT

Objective: To determine the clinical efficacy of echocardiography in assessing diastolic function in football players who have experienced myocardial infarction with preserved ejection fraction heart failure. **Methods:** This study involved 54 football players with myocardial infarction and preserved ejection fraction heart failure, treated at our medical center from September 2020 to January 2021. They were compared to 50 healthy, physically active volunteers. Both groups underwent echocardiographic evaluations focusing on cardiac structure and function. The quality of life of the football players was assessed before and after the echocardiographic evaluations. **Results:** The observation group showed elevated serum levels of troponin I (cTnI) and N-terminal B-type natriuretic peptide (NT-proBNP) compared to the control group ($P < 0.05$). Echocardiographic findings indicated significant differences in diastolic function between groups, with the E/A ratio and E/E' ratio notably higher in the observation group. Post-treatment, the quality of life in the observation group improved significantly ($P < 0.05$). **Conclusion:** Echocardiography is a valuable clinical tool for evaluating diastolic function in football players who have suffered myocardial infarction with preserved ejection fraction heart failure, especially post-stenting. This study highlights the importance of specialized cardiac assessments in athletes to facilitate optimal recovery and athletic performance.

KEY WORDS: Myocardial infarction with preserved ejection fraction heart failure; Football Players; Stent implantation; Diastolic dysfunction; Athlete

Heart Health

1. INTRODUCTION

Cardiovascular health in athletes, particularly those engaged in high-intensity sports like football, has been a subject of growing concern and study. In this clinical research, we delve into a critical aspect of this area by evaluating diastolic function in football players who have experienced myocardial infarction (MI) and have preserved ejection fraction heart failure (HFpEF). The study employs echocardiography, a key non-invasive diagnostic tool, to assess the impact of these cardiac events on the heart's diastolic function in this specific athletic population(Lyu et al., 2022). Heart failure with preserved ejection fraction, a condition where the heart muscle contracts normally but the ventricles do not relax as they should during diastole, is increasingly recognized in patients with a history of myocardial infarction. While HFpEF is commonly studied in the general population, its dynamics in athletes, particularly those who have suffered an MI, are not well understood(Soares, Losada, Jordani, Évora, & Castro-e-Silva, 2019).

This gap in knowledge is especially relevant for football players, who engage in a sport that demands both endurance and explosive power, placing unique stresses on the cardiovascular system(Wu, Wu, & Ni, 2019). The rationale behind focusing on football players stems from the sport's intense physical demands, which can have both beneficial and adverse effects on heart health. On one hand, regular, intense exercise is known to promote cardiovascular fitness; on the other hand, it can also lead to specific cardiac adaptations, sometimes referred to as "athlete's heart", and potentially exacerbate underlying conditions. Understanding how MI and HFpEF interact in this context is crucial for developing tailored health strategies for these athletes(Davin et al., 2018). Echocardiography offers an ideal diagnostic tool for this study due to its ability to provide detailed images of the heart's structure and function without being invasive.

This technique is particularly adept at assessing diastolic function, allowing for precise measurement of how the heart fills with blood and how well the ventricles relax - critical factors in HFpEF(Wester et al., 2019). This clinical study aims to provide comprehensive insights into the diastolic function among football players with a history of myocardial infarction who are diagnosed with HFpEF. By focusing on this group, we seek to understand the specific cardiac challenges they face, contributing to the broader field of sports cardiology(Rasmussen et al., 2019). Our findings aim to inform clinical practices regarding the monitoring, treatment, and guidance provided to athletes in managing their cardiovascular health post-MI, ultimately aiding in the development of targeted strategies to ensure their well-being and longevity in the sport.

2. GENERAL INFORMATION AND METHODS

2.1 General Information

A total of 54 patients with myocardial infarction complicated with ejection fraction reserved heart failure admitted to our Medical Center from September 2020 to January 2021 were selected as the research objects and divided into the observation group. Another 50 healthy volunteers were selected and divided into control group. The observation group received ultrasonic electrocardiogram evaluation after stent implantation, and the control group received ultrasonic electrocardiogram evaluation at the same time. This study has been approved by the Ethics Committee of our hospital and informed consent of patients has been obtained.

2.2 Inclusion criteria and exclusion criteria

Inclusion criteria :(1) age >18; (2) According to the clinical manifestations, the patient was diagnosed as myocardial infarction combined with retained ejection fraction heart failure; (3) Left ventricular ejection fraction ≤40%, systolic blood pressure <140 mm Hg, blood potassium ≤5 mmol/L; (4) There were no contraindications and the operation was well controlled; (5) Good compliance.

Exclusion criteria :(1) prior to admission, there was a history of intracranial or spinal surgery; (2) Close head injury, facial trauma and other accidents occurred within 3 months; (3) Heart failure was mainly caused by right ventricular failure, pericardial disease or congenital heart disease. (4) hepatic and renal insufficiency with electrolyte disorder; (5) with coagulation dysfunction, severe thrombocytopenia, etc.; (6) severe hypotension and sinus bradycardia; (7) Severe hypertension (blood pressure > 180/110 mmHg).

3. METHODS

The observation group underwent stent implantation first, and the specific measures were as follows. The skin was routinely disinfected, 2% lidocaine was used for local anesthesia, arterial access was established, the stent was placed in the stage of coronary artery stenosis, and the placement of the stent was examined to determine whether the vessel wall could be supported. Both groups were examined for cardiac structure and function, and the specific measures were as follows: Diastolic dysfunction classification is based on guidelines developed by the American Society of Echocardiography and the European Association of Cardiovascular Imaging. Color ultrasonic diagnostic instrument (Philips, model: HD15) was used for diagnosis, frequency of 2 ~ 4mhz. Client breathing peacefully, left decubitus position. The short axial section of the left ventricle was scanned through the papillary muscular section, and electrocardiogram was displayed synchronously. Each measured value was continuously measured for 3 cardiac cycles. The mean value of the left ventricular wall thickness, left ventricular relative wall thickness, diastolic function; (2) Left ventricular ejection fraction (LVEF) and Left ventricular end-diastolic volume; LVEDV, left ventricular end-systolic volume (LVESV), and Left atrial volume index (LAVI) were measured by Left atrial tracking technique. (3) Left ventricular mass index (LVMI) refers to the ratio of Left ventricular weight to body surface area. The data of Left ventricular weight are measured by measuring the Left ventricular diameter at the end of diastolic period, the thickness of ventricular septum, and the thickness of Left ventricular posterior wall in 3 consecutive times.

The mean value was obtained by Devereux's ventricular weight correction formula. (4) Deceleration Time (DT), which is to measure the flow deceleration time of mitral valve from peak-to-peak value to zero calibration level. (5) E/A ratio: that is, measure the maximum filling velocity in early and late diastole (PEAK E and peak A) and calculate E/A ratio; (6) E/ E 'ratio: E is the blood flow velocity through the mitral valve in early left ventricular diastole, and E' is the motion velocity of mitral valve ring in early left ventricular diastole on tissue Doppler. A sampling line was placed on the anterior septum and posterior wall of the mitral annulus to record the peak velocity of the mitral annulus in early diastolic period and measure the ratio between the two.

3.1 Serum detection

6ml of venous blood from the median of the elbow was collected from all subjects on an empty stomach, and heparin 12.5×103U/L was anticoagulant, which was placed in a centrifuge. After centrifugation at 3000 r/min for 10 minutes, the upper serum was absorbed, and the samples were stored in a refrigerator at -20℃. Serum troponin I (cTnI) level was determined by chemiluminescence immunoassay. The serum levels of N-terminal B-type pronatriuretic peptide (NT-pro BNP) were determined by double-antibody sandwich enzyme-linked immunosorbent assay (ELISA).

3.2 follow-up

The follow-up included medical history, blood test and echocardiography. All - cause deaths and end - point events during hospitalization and after discharge were recorded once every 2 months.

3.3 Observation Indicators

(1) The levels of relevant serum indexes were compared between the two groups. (2) Ventricular function and ventricular structure were compared between the two groups. (3) The average quality of life of subjects in the observation group before intervention and after discharge was compared using the brief Health Questionnaire (SF-36) (Kalyoncuoğlu et al., 2021). The scale

includes general health, physical pain, physiological function, mental health, vitality, emotional function, social function and so on. Each score is 100 points, and the higher the score, the better the patient's quality of life.

3.4 Statistical Processing

SPSS 23.0 statistical software was used to analyze the data. The measurement data in accordance with normal distribution were expressed as mean ± standard deviation (± S), and t-test was used for comparison between groups. Statistical data were expressed as case number (n) or percentage (%), and data were compared by χ2 test. When P < 0.05, the difference was statistically significant.

4. RESULTS

4.1 General Information

The differences in gender, age, Body Mass Index (BMI) and other general data of subjects in the two groups were not statistically significant (P > 0.05), and were comparable, as shown in Table 1.

Table 1 Comparison of general data between the two groups of subjects

GROUP		CONTROL GROUP (N=50)	OBSERVATION GROUP (N=54)	STATISTICS	P
Gender	Male	26	33	3.568	0.054
	Female	24	21		
Age (years)		67.54±5.22	67.52±5.23	1.252	0.062
BMI（kg/m²）		22.84±2.36	22.34±2.64	0.874	0.312

4.2 The serum levels of the two groups were compared

The levels of cTnI and NT-PRO BNP in the control group were significantly better than those in the control group, and the differences were statistically significant (P < 0.05), as shown in Fig 1.

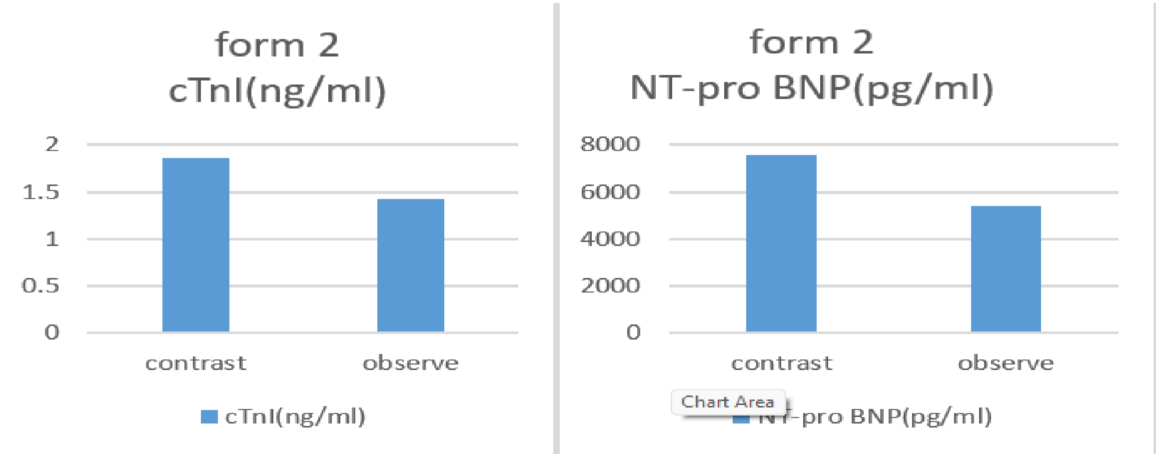

Figure 1

4.3 Comparison of ventricular function and ventricular structure between the two groups

The ventricular function and ventricular structure level of subjects in the control group were significantly better than those in the control group, and the difference was statistically significant (P < 0.05), as shown in Table 2.

Table 2 Comparison of diastolic function between the two groups

GROUP	CONTROL GROUP (N=50)	OBSERVATION GROUP (N=54)	STATISTICS	P
Mild disabilities	4（0.80）	29（53.70）	10.568	0.000
Moderate disabilities	0（0.00）	25（26.30）	8.252	0.001
Severe obstacle	0（0.00）	0（0.00）	0.000	1.000

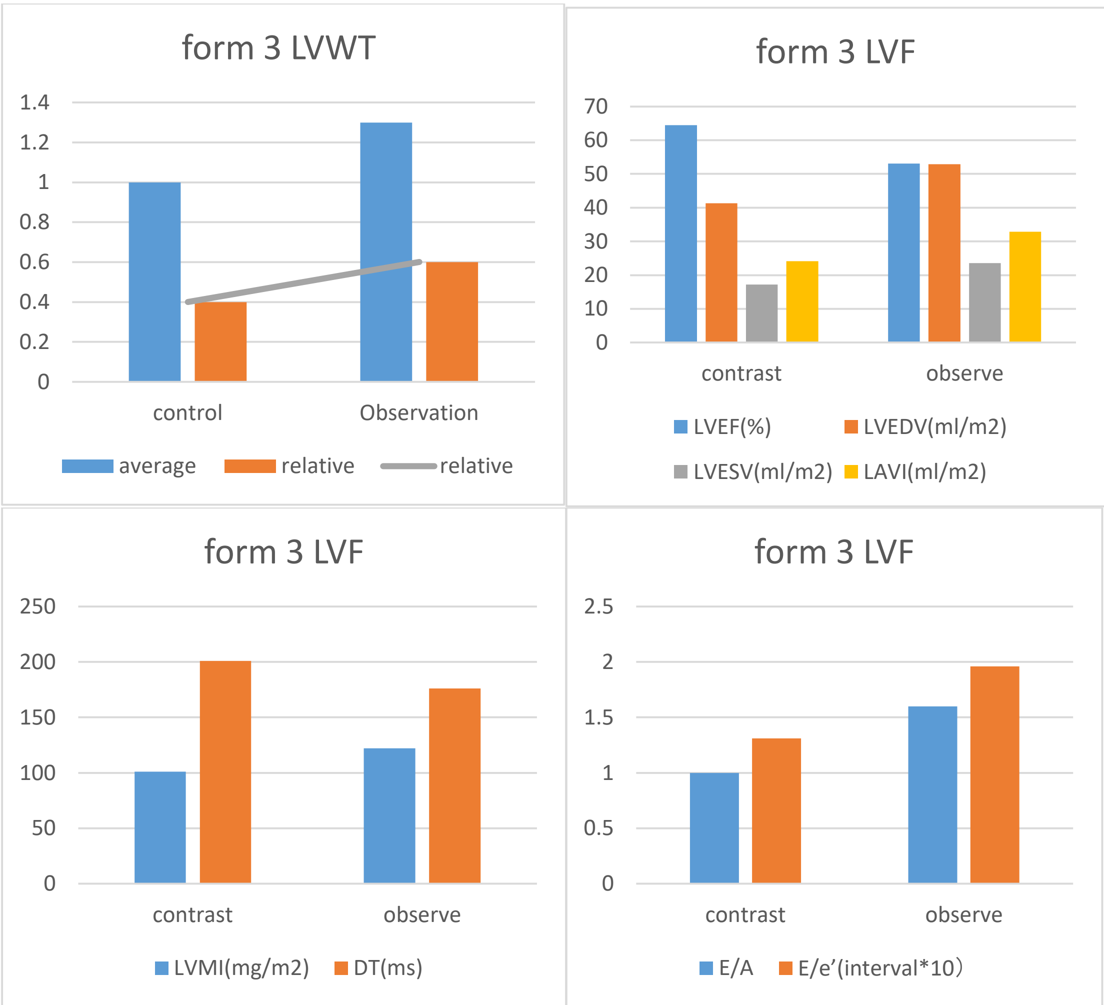

Figure 2

4.4 Comparison of quality of life of observation group before and after treatment

After treatment, the quality of life of the observation group was significantly higher than that before treatment, and the difference was statistically significant (P < 0.05), as shown in Figure 3.

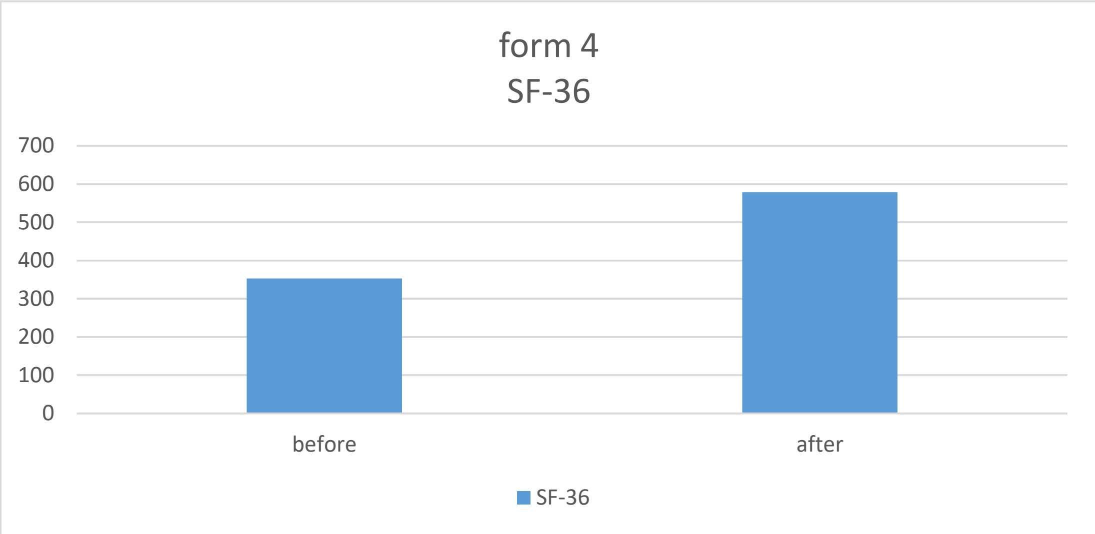

Figure 3

5. DISCUSSION

As a disease of cardiovascular system, myocardial infarction is characterized by dangerous onset, high disability rate and high mortality (Kochar et al., 2018). It is caused by coronary artery disease, such as inflammation, spasm, coronary embolism, and coronary mouth occlusion, resulting in stenosis of one or more lumens. At this point, if collateral circulation is not fully established and coronary artery blood supply is interrupted or reduced, persistent ischemic injury and necrosis of myocardium can be caused (Nguyen, Bui, Tran, Le, & Nguyen, 2020). Clinically, it is characterized by severe and persistent retrosternal pain accompanied by increased markers of serum myocardial injury and progressive ecg changes, which can induce symptoms such as malignant arrhythmia and heart failure (Rasmussen et al., 2019). According to the pathophysiological characteristics and the difference of ejection fraction, heart failure can be classified into heart failure with retained ejection fraction. It is mainly caused by enlarged stiffness of the heart cavity, damage of ventricular active relaxation ability, and damage of filling leads to decreased cardiac volume and significant increase of ventricular diastolic membrane pressure. Heart failure induced by normal systolic function is a serious threat to patients' health and life safety (Caridi-Scheible, Nichols, & Gallagher, 2021).

At present, it is clinically believed that the key to the treatment of patients with this disease is to completely open the infarct-related artery at an early stage, and stent implantation can achieve early myocardial reperfusion, which is an important treatment method for clinical rescue of myocardial necrosis(Gandhi, Robert, Palacios, & Chan, 2022). It reduces the resistance of myocardium to work, lowers blood pressure, slows heart rate, and reduces the amount of oxygen consumed by myocardium. However, this treatment process can induce postoperative thrombosis, chills and delirium and other complications, affecting the prognosis of patients (Kaura et al., 2020; Sliman et al., 2019).

In this study, Doppler echocardiography showed restricted filling abnormal waveform or "false normalization" waveform before stent implantation. This indicates that the patient has a large myocardial infarction, abnormal left ventricular diastolic function, and a more serious condition. After treatment, the patient's image showed a relaxed abnormal filling waveform, indicating that the infarcted myocardium healed and the infarct scope was reduced. At the same time, the degree of damage of left ventricular diastolic function decreased and diastolic function gradually improved. Nt-pro BNP is a neurohormone secreted by myocardial cells of the left ventricle. With the aggravation of the disease, the secretion of BNP increases, and its concentration is a sensitive indicator of cardiac function. CTnI is a specific contractile regulating protein of myocardium, which can be released rapidly when myocardium is damaged and is one of the most sensitive and specific serological markers of myocardial injury (Katritsis & Ioannidis, 2005) (Interventions, 2010). This study found that after treatment, the quality of life of subjects in the observation group was significantly higher than before treatment, and the serum troponin I and N-terminal B-type natriuretic peptide levels in the control group were significantly higher than those in the control group, with statistically significant differences. It is suggested that after stenting, the blood vessels dilate and improve the blood and oxygen supply to the myocardium. At the same time, can strengthen the myocardial contractility, promote cardiac contraction, improve cardiac output. Reduce the load of the heart before and after, improve cardiac remodeling, increase the normal performance of the blood pumping function and diastolic function of the heart, and improve cardiac circulation (Ohana-Sarna-Cahan & Atar, 2018).

At the same time, by regulating the nervous and endocrine systems of patients, the oxidative stress response can be reduced, cell apoptosis can be reduced, and myocardial cells can be improved and protected. Thus, the concentration of serum troponin I and N-terminal B-type pronatriuretic peptide can be reduced to alleviate the symptoms of patients and improve their quality of life (Pei et al., 2018). With the continuous maturation of imaging technology, echocardiography has been widely used in the evaluation of left ventricular diastolic function due to its advantages of non-invasive, high sensitivity and simple operation (Jiang et al., 2020). It has been reported that diastolic function may be affected by age-related muscle cell loss or hypertrophy, interstitial fibrosis, impaired cellular calcium uptake, etc. Impaired function may lead to clinical symptoms and decompensation through elevated pulmonary venous pressure (Gargiulo et al., 2019). This study found that the average left ventricular wall thickness, relative left ventricular wall thickness and diastolic function of subjects in the control group; Left ventricular ejection fraction, left ventricular end diastolic volume, left ventricular end systolic volume, left atrial volume index; Left ventricular mass index. E peak deceleration time; E/A ratio. The E/ E 'ratio level was significantly better than that of the control group, and the difference was statistically significant, which was similar to reports in related studies. The reason was that the ventricular diastolic function was limited, and the increase of ventricular filling pressure led to the increase of capillary wedge pressure, which then led to the increase of ventricular end-diastolic pressure.

The decrease of stroke output further causes the thickening of the posterior wall of the left ventricle and ventricular septum, which is closely related to the diastolic function of the left ventricle as can be seen from related parameters of ultrasonic electrocardiogram (Lim et al., 2021). Some studies have suggested that when patients' cardiomyocytes are stimulated to a certain extent, corresponding action potentials can be generated. Its prolongation leads to an increase in the concentration of calcium ions in the cardiomyocytes, further increasing the tension of the ventricular muscles. If the action potential is prolonged for a long time, the diastolic function of the heart will be damaged, and then the related value changes will be caused (König et al., 2020). Studies have shown that simultaneous major impairment of left ventricular function and poor longitudinal systolic function of the left ventricle can lead to dysfunction or reduced systolic dilation due to the decline of the mitral valve plane during ventricular contraction. It was found that a decrease in compliance could lead to an increase in any given diastolic pressure, resulting in a higher E-wave velocity and E/ E 'ratio.

6. Conclusion:

This study on diastolic function in football players who have had myocardial infarction (MI) with preserved ejection fraction heart failure (HFpEF), using echocardiography, reveals crucial insights about the cardiovascular health in athletes. The findings highlight the unique diastolic characteristics in this group, differentiating them from the general HFpEF population, likely due to their rigorous training and resulting cardiac adaptations. Key observations include altered diastolic function despite a preserved ejection fraction, underscoring the need for specialized cardiac care post-MI in athletes. These insights call for tailored strategies in managing HFpEF in sports professionals, diverging from standard treatments used for the general population.

The study emphasizes the importance of advanced cardiac monitoring and personalized treatment approaches for athletes, contributing significantly to sports cardiology. It underscores the need for updated screening and monitoring protocols in athletic healthcare, ensuring effective management of cardiac health in this high-risk group. This research is a step forward in optimizing cardiovascular care for athletes, ensuring their health and longevity in sports.

REFERENCES

Caridi-Scheible, M., Nichols, K., & Gallagher, J. (2021). Bivalirudin in Venovenous Extracorporeal Membrane Oxygenation: Moving Forward in the Real World. *Critical Care Medicine, 49*(7), 1208-1210.

Davin, L., Marechal, P., Lancellotti, P., Martinez, C., Pierard, L., & Radermecker, R. (2018). Angioedema: a rare and sometimes delayed side effect of angiotensin-converting enzyme inhibitors. *Acta Cardiologica*.

Gandhi, P., Robert, M. A., Palacios, J., & Chan, D. (2022). Effects of Contact Tracing and Self-Reporting in a Network Disease Model. *Letters in Biomathematics, 9*(1), 23–39. doi:10.30707/LiB9.1.1681913305.219107

Gargiulo, G., Carrara, G., Frigoli, E., Leonardi, S., Vranckx, P., Campo, G., . . . Bartolini, D. (2019). Post-procedural bivalirudin infusion at full or low regimen in patients with acute coronary syndrome. *Journal of the American College of Cardiology, 73*(7), 758-774.

Interventions, E. A. f. P. C. (2010). The task force on myocardial revascularization of the European Society of Cardiology (ESC) and the European Association for Cardio-Thoracic Surgery (EACTS). *Eur Heart J, 31*, 2501-2555.

Jiang, J., Chen, Q., Chen, X., Li, J., Li, S., & Yang, B. (2020). Magnesium sulfate ameliorates sepsis-induced diaphragm dysfunction in rats via inhibiting HMGB1/TLR4/NF-κB pathway. *NeuroReport, 31*(12), 902.

Kalyoncuoğlu, M., Katkat, F., Biter, H. I., Cakal, S., Tosu, A. R., & Can, M. M. (2021). Predicting one-year deaths and major adverse vascular events with the controlling nutritional status score in elderly patients with non–st-elevated myocardial infarction undergoing percutaneous coronary intervention. *Journal of Clinical Medicine, 10*(11), 2247.

Katritsis, D. G., & Ioannidis, J. P. (2005). Percutaneous coronary intervention versus conservative therapy in nonacute coronary artery disease: a meta-analysis. *Circulation, 111*(22), 2906-2912.

Kaura, A., Sterne, J. A., Trickey, A., Abbott, S., Mulla, A., Glampson, B., . . . Omigie, J. (2020). Invasive versus non-invasive management of older patients with non-ST elevation myocardial infarction (SENIOR-NSTEMI): a cohort study based on routine clinical data. *The Lancet, 396*(10251), 623-634.

Kochar, A., Chen, A. Y., Sharma, P. P., Pagidipati, N. J., Fonarow, G. C., Cowper, P. A., . . . Wang, T. Y. (2018). Long-term mortality of older patients with acute myocardial infarction treated in US clinical practice. *Journal of the American Heart Association, 7*(13), e007230.

König, K. S., Verhaar, N., Hopster, K., Pfarrer, C., Neudeck, S., Rohn, K., & Kästner, S. B. (2020). Ischaemic preconditioning and pharmacological preconditioning with dexmedetomidine in an equine model of small intestinal ischaemia-reperfusion. *Plos one, 15*(4), e0224720.

Lim, H., Kim, T. Y., Kim, S. Y., Ro, S. J., Koh, S. R., Ryu, S., . . . Jeong, M. A. (2021). *The protective effects of dexmedetomidine preconditioning on hepatic ischemia/reperfusion injury in rats.* Paper presented at the Transplantation Proceedings.

Lyu, S.-q., Zhu, J., Wang, J., Wu, S., Zhang, H., Shao, X.-h., & Yang, Y.-m. (2022). Validation of the Academic Research Consortium for High Bleeding Risk criteria in Chinese patients with atrial fibrillation and acute coronary syndrome or undergoing percutaneous coronary intervention. *Thrombosis Research, 209*, 16-22.

Nguyen, T. V., Bui, K. X., Tran, K. D., Le, D., & Nguyen, T. N. (2020). Non-ST elevation acute coronary syndrome in patients aged 80 years or older in Vietnam: An observational study. *Plos one, 15*(6), e0233272.

Ohana-Sarna-Cahan, L., & Atar, S. (2018). Clinical outcomes of patients with acute coronary syndrome and moderate or severe chronic anaemia undergoing coronary angiography or intervention. *European Heart Journal: Acute Cardiovascular Care, 7*(7), 646-651.

Pei, W., Zou, Y., Wang, W., Wei, L., Zhao, Y., & Li, L. (2018). Tizanidine exerts anti-nociceptive effects in spared nerve injury model of neuropathic pain through inhibition of TLR4/NF-κB pathway. *International journal of molecular medicine, 42*(6), 3209-3219.

Rasmussen, E. R., Pottegård, A., Bygum, A., von Buchwald, C., Homøe, P., & Hallas, J. (2019). Angiotensin II receptor blockers are safe in patients with prior angioedema related to angiotensin-converting enzyme inhibitors–a nationwide registry-based cohort study. *Journal of Internal Medicine, 285*(5), 553-561.

Sliman, H., Jaffe, R., Rubinshtein, R., Karkabi, B., Zissman, K., Flugelman, M. Y., & Zafrir, B. (2019). Clinical features and outcomes of revascularization in very old patients with left main coronary artery disease. *Coronary artery disease, 30*(8), 584-589.

Soares, R. O., Losada, D. M., Jordani, M. C., Évora, P., & Castro-e-Silva, O. (2019). Ischemia/reperfusion injury revisited: an overview of the latest pharmacological strategies. *International journal of molecular sciences, 20*(20), 5034.

Wester, A., Attar, R., Mohammad, M. A., Andell, P., Hofmann, R., Jensen, J., . . . Koul, S. (2019). Impact of baseline anemia in patients with acute coronary syndromes undergoing percutaneous coronary intervention: a prespecified analysis from the VALIDATE-SWEDEHEART trial. *Journal of the American Heart Association, 8*(16), e012741.

Wu, H.-Y., Wu, J.-L., & Ni, Z.-L. (2019). RETRACTED ARTICLE: Overexpression of microRNA-202-3p protects against myocardial ischemia-reperfusion injury through activation of TGF-β1/Smads signaling pathway by targeting TRPM6. *Cell cycle, 18*(5), 621-637.