Int Cardiovasc Res J.2020;**14**(2):42-47.icrj.103597

International Cardiovascular Research Journal

www.ircrj.com

# Atrial Fibrillation as a Risk Marker in Patients with Decompensated Heart Failure

Maryam Nabati [1, *], Soheil Bakhshinasab [2], Ali Asghar Farsavian [1], Fatemeh Rasolpor [2], Jamshid Yazdani-Charati [3]

[1] Department of Cardiology, Faculty of Medicine, Cardiovascular Research Center, Mazandaran University of Medical Sciences, Sari, IR Iran
[2] Student Research Committee, Faculty of Medicine, Cardiovascular Research Center, Mazandaran University of Medical, Sciences, Sari, IR Iran
[3] Department of Biostatics, Faculty of Health, Mazandaran University of Medical Sciences, Sari, IR Iran

ARTICLE INFO

*Article Type:*
Research Article

*Article History:*
Received: 10 Apr 2020
Revised: 21 May 2020
Accepted: 31 May 2020

*Keywords:*
Heart Failure
Atrial Fibrillation
Echocardiography
Right Ventricular Dysfunction

ABSTRACT

**Background:** Atrial Fibrillation (AF) and Heart Failure (HF) most commonly coexist, and each condition can exacerbate and complicate the course of treatment of the other. The relationship between these two conditions is not entirely understood. Loss of atrial systole is an important contributing factor in decreasing cardiac output and can increase the risk of blood stasis, thromboembolism, inflammation, and cardiac myocyte dysfunction.

**Objective:** This study aimed to assess the relationship between AF and cardiovascular mortality and high-risk clinical, laboratory, and echocardiographic variables in patients with acute decompensated HF.

**Methods:** This historical cohort study was conducted on 298 consecutive patients admitted with acute decompensated HF. The patients were divided into sinus rhythm (198 patients, 66.44%) and AF (100 patients, 33.56%) groups. The two groups were compared regarding demographic, laboratory, and echocardiographic variables and cardiovascular mortality within six months after index hospitalization using independent t-test, chi-square, and Fisher's exact tests. In addition, independent echocardiographic risk factors for development of AF were determined by a logistic regression model. Variables with $P < 0.05$ were considered to be significant. All statistical analyses were done by SPSS/PASW software.

**Results:** The results showed that the patients with AF were older and had female predominance, a lower prevalence of diabetes mellitus, a lower rate of glomerular filtration, and a higher six-month cardiovascular mortality compared to those with sinus rhythm ($P = 0.011$, 0.05, 0.005, 0.043, and 0.041, respectively). These patients also had a larger left atrial diameter ($P < 0.001$) and a higher prevalence of right ventricular enlargement, systolic dysfunction, and moderate or severe functional mitral regurgitation compared to those with sinus rhythm ($P = 0.02$, 0.016, and 0.011, respectively). The results of logistic regression analysis indicated that left atrial diameter was the only independent predictor of AF (odds ratio = 2.27, 95% confidence interval [1.38 – 3.75]).

**Conclusion:** The results showed that AF was associated with increased cardiovascular mortality and high-risk clinical, laboratory, and echocardiographic markers in patients with decompensated HF.

## 1. Background

Atrial Fibrillation (AF) and Heart Failure (HF) are two growing epidemics, which most commonly coexist, and each condition can exacerbate and complicate the course of treatment of the other (1). The relationship between these two conditions is not entirely clear. An increase in heart rate shortens the diastolic filling period, resulting in a decrease in cardiac output. Loss of atrial systole is also an important contributing factor to decrease in the cardiac output. New onset AF in individuals with HF has been reported to be associated with a sudden worsening of the patients' symptoms, peak oxygen consumption, decrease in cardiac index, and increase in the severity of mitral and tricuspid

*Corresponding author: Maryam Nabati, Artesh Boulevard, Fatemeh Zahra Teaching Hospital, Sari, Iran. Tel: +98-1133324002, Fax: +98-1133324002, Email: dr.mr.nabati@gmail.com.

regurgitation (2, 3). Both of these conditions can increase the risk of blood stasis, thromboembolism, inflammation, and cardiac myocyte dysfunction.

The increasing burden of cardiovascular risk factors in developing countries contributes to the rising number of individuals who develop both AF and HF (4). Considering how HF and its consequences can deeply affect general healthcare issues, it is important to know more about some of the most important complications, such as AF.

## 2. Objectives

This study aims to assess the relationship between AF and cardiovascular mortality and high-risk clinical, laboratory, and echocardiographic variables in patients with acute decompensated HF.

## 3. Patients and Methods

This historical cohort study was conducted on 298 consecutive patients admitted with acute decompensated HF (New York Heart Association [NYHA] functional class IV) to Fatemeh Zahra Hospital between 2018 and 2019 (5). The minimum sample size was determined based on the results of the previous studies and using the following formula (3):

$$n1 = n2 = \frac{2\times(z_{\frac{\alpha}{2}} + z_{\beta})^2\sigma^2}{(\mu_1 - \mu_2)^2} = 98,\ \ 100, \alpha = 0.05, \beta = 0.2, \sigma = 5, \mu_1 = 58, \mu_2 = 56$$

The diagnosis of acute decompensated HF was made with typical symptoms and signs of HF (e.g., orthopnea, fine pulmonary crackles, tachypnea, and hypoxia). This study was done according to the guidelines of Helsinki Declaration and was approved by the Ethic Committee of the hospital (ethical approval code: IR.MAZUMS.REC.1399.243). Written informed consent forms were also obtained from all participants. The patients were divided into two groups: one group with sinus rhythm and the other group with permanent or paroxysmal AF detected by electrocardiogram either on admission or during the hospital stay. AF was identified by lack of a P-wave and irregular QRS complexes due to rapid and disorganized atrial activation (6). Patients with immune disease, neoplasm, collagen vascular disease, fever, septicemia, atrioventricular conduction defect, primary valvular heart disease, acute ST-segment elevation myocardial infarction, and restrictive or hypertrophic cardiomyopathy and pregnant women were excluded from the study. Diabetes Mellitus (DM) was diagnosed based on the guidelines of the American Diabetes Association or the need for taking insulin or oral hypoglycemic agents (7). Hypertension (HTN) was considered as having a Systolic Blood Pressure (SBP) ≥ 140 mmHg, a Diastolic Blood Pressure (DBP) ≥ 90 mm Hg, or need for using antihypertensive medications (8). Family History (FH) of Coronary Artery Disease (CAD) was characterized by having a male first degree relative with CAD younger than 55 years or a female one younger than 65 years of age (9). Hyperlipidemia (HLP) was defined as total cholesterol levels above 200 mg/dL and high-density lipoprotein-cholesterol levels below 40 mg/dL in males or below 50 mg/dL in females (10). The history of smoking was determined using a questionnaire completed in a face-to-face manner. Systolic and diastolic blood pressures were measured on admission. Body Mass Index (BMI) was calculated using the following formula: BMI = weight (kg)/m2. Blood samples were also obtained at the time of admission and plasma potassium, sodium, magnesium, blood urea nitrogen, and creatinine levels were determined. Besides, Glomerular Filtration Rate (GFR) was calculated using the following formula (15% less in females) (11): GFR = (140- age) (weight in kg) / 72 × serum Cr (mg/dL). Finally, troponin I values more than 0.2 ng/mL were considered elevated (12).

The two groups were compared with respect to baseline demographic, laboratory, and echocardiographic characteristics and six-month readmission and mortality. The patients were followed up by phone call or by checking their medical records to determine the occurrence and causes of death and readmission rates.

### *3.1. Echocardiography*

A transthoracic echocardiography was performed in all patients by a Vivid S5 (GE Healthcare, Wauwatosa, WI) during the first 24 hours of admission. All images were stored on a hard disk. One experienced echocardiographer blinded to the patients' data was requested to interpret the echocardiographic images. Left Ventricular Ejection Fraction (LVEF) was determined in both apical two- and four-chamber views by subtracting the Left Ventricular End-Systolic Volume (LVESV) from the Left Ventricular End-Diastolic Volume (LVEDV) divided by LVEDV using the biplane Simpson's technique. Left Atrial (LA) antero-posterior diameter was defined as the end-systolic vertical distance between the posterior edge of the aorta and the posterior LA wall in the para-sternal long axis. LA was considered enlarged if the diameter was more than 3.8 cm in females and more than 4 cm in males. Right Ventricular (RV) enlargement was defined as a diameter of greater than 4.1 cm at the base and 3.5 cm in the mid-level in an RV-focused four-chamber view. RV systolic dysfunction was considered when Tricuspid Annular Plane Systolic Excursion (TAPSE) was less than 17 mm (13). Diastolic dysfunction was also determined based on the guidelines of the American Society of Echocardiography. The patients were classified into three diastolic dysfunction grades: grade I with normal filling pressures and grades II and III with elevated filling pressures (14). Functional Mitral Regurgitation (MR) was defined as a regurgitation occurring with a structurally normal Mitral Valve (MV) with apical tethering of leaflets and dilated annuli. Considering MR severity, the patients were divided into two groups; group 1 had no or mild MR and group 2 manifested moderate or severe MR (15). Pulmonary Arterial Pressure (PAP) was derived from the peak Tricuspid Regurgitation (TR) velocity and Right Atrial (RA) pressure. A value greater than 35 mmHg was considered as Pulmonary Arterial Hypertension (PAH) (16).

### *3.2. Statistical Analysis*

Continuous variables were presented by mean + standard deviation and categorical variables were shown by

frequency and percentage. Independent t-test was utilized to compare the continuous variables and chi-square and Fisher's exact tests were used to compare the categorical ones. A logistic regression model was also performed to determine the independent echocardiographic risk factors for development of AF. All statistical analyses were done by SPSS/PASW 18 software (SPSS Inc., Chicago, IL), and $P < 0.05$ was considered to be significant.

## 4. Results

This study was conducted on 298 patients (140 males and 158 females) who were admitted with the diagnosis of acute decompensated HF with an LVEF < 50%. The most common cardiovascular risk factor was HTN (185 patients, 62.08%) followed by DM (141 patients, 47.31%), HLP (130 patients, 43.62%), FH (50 patients, 16.78%), and smoking (36 patients, 12.08%). The mean LVEF was 25.13 ± 10.53%. Moderate or severe functional MR was seen in 209 patients (70.13%) and grade II-III diastolic dysfunction was detected in 272 patients (91.27%). Additionally, RV enlargement and systolic dysfunction were seen in 95 (31.88%) and 128 patients (42.95%), respectively. The mean LA diameter was 4.36 ± 0.89.

As mentioned above, the patients were divided into sinus rhythm (198 patients, 66.44%) and AF (100 patients, 33.56%) groups. Demographic characteristics, six-month readmission rates, and cardiovascular mortality of the two study groups have been presented in Table 1. Accordingly, the AF patients were older and had a female predominance of 61% compared to the sinus rhythm group (P = 0.011 and 0.05, respectively). In addition, DM was less prevalent in the AF group. The prevalence of DM was 42.9% (60 patients) in males and 51.3% (81 patients) in females, but the difference was not statistically significant (P = 0.164). Besides, the AF group showed a lower GFR in comparison to the sinus rhythm group (P = 0.005 and 0.043, respectively). Among the echocardiographic variable, LA diameter was larger in the AF group compared to the sinus rhythm group (P < 0.001). Moreover, the prevalence of RV enlargement and systolic dysfunction was higher in the AF group compared to the sinus rhythm group (P = 0.02 and 0.016, respectively). The prevalence of moderate or severe functional MR was also higher among the AF patients compared to those with sinus rhythm (P = 0.011) (Table 2, Figures 1 and 2).

During the six-month follow-up, there were 1.5% cardiovascular deaths in the sinus rhythm group in comparison to 6% among the AF patients (P = 0.041). The results of the logistic regression analysis showed that among different echocardiographic variables, LA diameter was the only independent predictor of AF (Table 3).

**Table 1.** Demographic Characteristics, Six-Month Readmission Rates, and Cardiovascular Mortality of the Study Population Categorized by Atrial Fibrillation Status

| | | Sinus Rhythm (N = 198) | Atrial Fibrillation (N = 100) | P-value |
|---|---|---|---|---|
| Age (years) | | 68.56 ± 13.91 | 72.96 ± 14.13 | 0.011 |
| Sex | Male | 101 (51%) | 39 (39%) | 0.05 |
| | Female | 97 (49%) | 61 (61%) | |
| Diabetes mellitus | | 105 (53.6%) | 36 (36.4%) | 0.005 |
| Hypertension | | 128 (65.3%) | 57 (57%) | 0.234 |
| Hyperlipidemia | | 91 (46.46%) | 39 (39%) | 0.545 |
| Smoking | | 28 (14.14%) | 8 (8%) | 0.121 |
| Systolic blood pressure (mmHg) | | 136.83 ± 31.59 | 133.38 ± 29.22 | 0.363 |
| Diastolic blood pressure (mmHg) | | 81.00 ± 18.27 | 77.69 ± 15.86 | 0.125 |
| Body mass index (kg/m$^2$) | | 27.29 ± 5.45 | 27.02 ± 6.16 | 0.716 |
| Family history | | 32 (16.16%) | 18 (18%) | 0.660 |
| Cardiovascular death | | 3 (1.5%) | 6 (6%) | 0.041 |
| Readmission rate | | 2.7 ± 6.02 | 2.65 ± 2.04 | 0.935 |

**Table 2.** Laboratory and Echocardiographic Characteristics of the Study Population Categorized by Atrial Fibrillation Status

| | Sinus Rhythm (n = 198) | Atrial Fibrillation (n = 100) | P-value |
|---|---|---|---|
| **Elevated serum troponin I** | 28 (14.14%) | 10 (10%) | 0.264 |
| **Sodium (meq/L)** | 137.18 ± 8.57 | 137.79 ± 10.83 | 0.595 |
| **Potassium (meq/L)** | 4.97 ± 4.47 | 4.49 ± 0.67 | 0.286 |
| **Magnesium (meq/L)** | 2.16 ± 0.34 | 2.26 ± 1.85 | 0.455 |
| **Blood urea nitrogen (mg/dL)** | 26.90 ± 19.32 | 29.84 ± 25.33 | 0.267 |
| **Creatinine (mg/dL)** | 1.67 ± 1.38 | 1.55 ± 1.15 | 0.458 |
| **Glomerular filtration rate (mL/min)** | 53.91 ± 34.75 | 47.23 ± 20.66 | 0.043 |
| **Left ventricular ejection fraction (%)** | 25.05 ± 11.40 | 26.00 ± 10.42 | 0.485 |
| **Left atrial diameter (cm)** | 4.14 ± 0.78 | 4.70 ± 0.95 | < 0.001 |
| **Pulmonary arterial pressure** | 43.60 ± 14.69 | 44.19 ± 14.60 | 0.812 |
| **Right ventricular enlargement** | 53 (26.8%) | 40 (40%) | 0.02 |
| **Right ventricular dysfunction** | 74 (37.4%) | 52 (52%) | 0.016 |
| **Diastolic dysfunction grade II-III** | 177 (89.4%) | 93 (93%) | 0.314 |
| **Moderate or severe functional mitral regurgitation** | 128 (64.6%) | 79 (79%) | 0.011 |

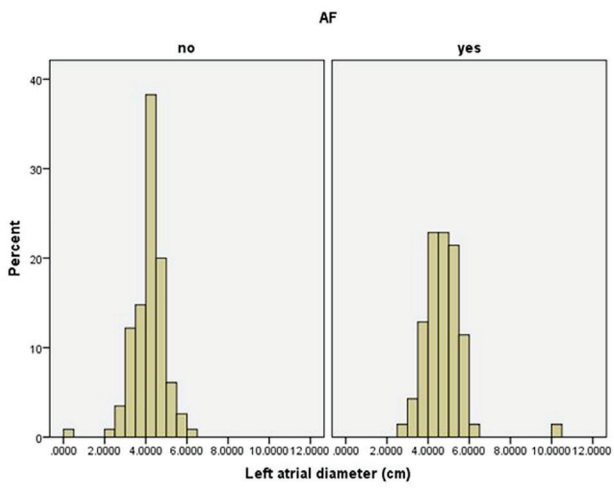


**Figure 1.** The Mean Left Atrial Diameter Histograms for Patients in the Sinus Rhythm and Atrial Fibrillation Groups (P < 0.001)

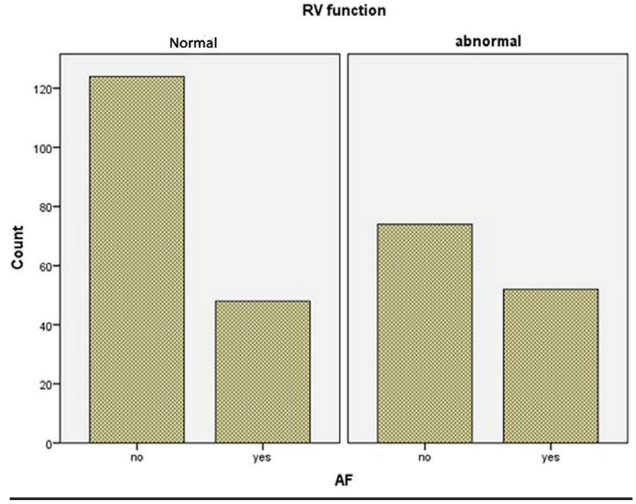


**Figure 2.** Bar Graphs Showing a Significant Difference between the Patients in the Sinus Rhythm and Atrial Fibrillation Groups regarding the Prevalence of RV Dysfunction (P = 0.016)

**Table 3.** Logistic Regression Analysis on Echocardiographic Predictors of Atrial Fibrillation

| | B | P-value | Exp (B) | 95% CI for Exp (B) | |
|---|---|---|---|---|---|
| | | | | Lower | Upper |
| **Left atrial diameter** | 0.821 | 0.001 | 2.272 | 1.377 | 3.750 |
| **Right ventricular enlargement** | 0.153 | 0.691 | 1.166 | 0.547 | 2.484 |
| **Right ventricular function** | 0.315 | 0.399 | 1.371 | 0.659 | 2.851 |
| **Mitral regurgitation** | 0.256 | 0.534 | 1.291 | 0.577 | 2.890 |
| **Diastolic dysfunction** | 0.247 | 0.671 | 1.281 | 0.410 | 4.003 |
| **Constant** | -4.990 | .001 | 0.007 | | |

## 5. Discussion

The present study findings showed that the patients with AF were older and had female predominance, a lower prevalence of DM, a lower GFR, and a higher six-month cardiovascular mortality compared to those with sinus rhythm. These patients also had a larger LA diameter and a higher prevalence of RV enlargement, systolic dysfunction, and moderate or severe functional MR in comparison to those with sinus rhythm. The prognostic importance of AF development in advanced HF is a controversial issue (4). Older studies, such as the Vasodilator-Heart Failure Trial (V-HeFT), have shown no significant difference between the patients with mild to moderate HF in AF and sinus rhythm groups regarding mortality. Other studies have reported the opposite finding, suggesting higher adverse effects of AF on mortality among the patients with mild to moderate HF compared with those with more severe HF (LVEF < 25%) (2). It seems that patients with AF and LV dysfunction had higher all-cause mortality and death due to pump failure compared to the patients with sinus rhythm (17). Consistently, the present study results demonstrated that mortality was higher in the patient with AF than in those with sinus rhythm. Moreover, the prevalence of AF increased from 10% in HF patients with NYHA class I to 50% in those with NYHA class VI (4). A study on patients admitted to hospital due to decompensated HF showed that the individuals who died during hospitalization were older and were more probable to be female and have AF and chronic kidney disease (18). In the current study, the patients with AF were older and had female predominance and a lower GFR compared to the other group. Hence, these people might be at a higher risk in comparison to other patients. Renal dysfunction in the setting of HF is usually caused by venous congestion and renal hypoperfusion. Activation of the neurohormonal system, inflammatory responses, and endothelial dysfunction also have some adverse mediating effects on promotion of microvascular injuries. Renal dysfunction is an important predictor of poor outcome and increased mortality in HF patients (19). Furthermore, patients with HF and DM had a lower prevalence of transient or permanent AF compared to non-diabetic HF patients (20). A study on HF patients with preserved EF showed an increased concentric LV remodelling, higher LV filling pressure, but a smaller LA volume among the patients with type 2 DM. Moreover, LA enlargement was strongly associated with AF, stroke, and cardiovascular mortality. Smaller LA volume in diabetics might be due to different pathophysiological mechanisms, including different biomarkers and extracellular matrix remodelling, compared to non-diabetics (21). In the present study, the lower prevalence of DM in patients with AF might be due to the fact that diabetics with HF usually have a lower LA volume compared to non-diabetics.

TAPSE is an index of RV function, which has a robust prognostic value in patients with HF. It is also a useful parameter in patients who have tachycardia or AF. This predictive value adds to the prognostic significance of NYHA functional classification and information obtained from the assessment of LV systolic and diastolic functions (22). In the current study, AF patients had a higher prevalence of RV enlargement and systolic dysfunction. Functional MR in patients with HF might be related to apical tethering of

leaflets secondary to LV remodelling. It should not only be considered as a consequence of ventricular remodelling, but it also has an additional adverse effect on LV remodelling, increased risk of AF, and the subsequent cardiovascular events (23). Similarly, the present study findings indicated that AF patients had a higher prevalence of moderate or severe functional MR compared to those with sinus rhythm.

### *5.1. Conclusion*

The findings of the present study showed that AF in patients with decompensated HF was associated with increased cardiovascular mortality and high-risk clinical, laboratory, and echocardiographic markers. Thus, AF in the setting of decompensated HF should be considered as a high-risk clinical situation, and special attention and close monitoring are required for patients with this arrhythmia during hospitalization or post-discharge.

### *5.2. Limitation*

One of the limitations of the current study was its small sample size. In addition, the follow-up period was only six months. Moreover, HF patients with AF, irrespective of whether this arrhythmia was permanent or transient, were included in the AF group. Therefore, their adverse effects on the aforementioned variables could not be determined separately.

### *5.3. Ethics Approval and Consent to Participate*

This study was approved by the Ethics Committee of Mazandaran University of Medical Sciences (ethical approval code: IR.MAZUMS.REC.1399.243). Written informed consent forms were also obtained from all participants.

**Acknowledgements**

This study was extracted from Mr. Soheil Bakhshinasab's B.Sc. thesis. Hereby, the authors would like to thank all patients and hospital staff for their cooperation and support.

**Authors' Contribution**

MN designed the study and wrote the manuscript; FR and SB collected the data; JY analyzed and interpreted the data; AF revised the manuscript critically for important intellectual content.

**Funding/Support**

There is no funding support.

**Financial Disclosure**

The authors have no financial interests related to the material in the manuscript.

**References**

1. Verma A, Kalman JM, Callans DJ. Treatment of patients with atrial fibrillation and heart failure with reduced ejection fraction. *Circulation*. 2017;**135**(16):1547-63.
2. Anter E, Jessup M, Callans DJ. Atrial fibrillation and heart failure: treatment considerations for a dual epidemic. *Circulation*. 2009;**119**(18):2516-25.
3. Lam CS, Rienstra M, Tay WT, Liu LC, Hummel YM, van der Meer P*, et al.* Atrial fibrillation in heart failure with preserved ejection fraction: association with exercise capacity, left ventricular filling pressures, natriuretic peptides, and left atrial volume. *JACC: Heart Failure*. 2017;**5**(2):92-8.
4. Batul SA, Gopinathannair R. Atrial Fibrillation in Heart Failure: a Therapeutic Challenge of Our Times. *Korean circulation journal*. 2017;**47**(5):644-62.
5. Ponikowski P, Voors AA, Anker SD, Bueno H, Cleland JG, Coats AJ*, et al.* 2016 ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure: The Task Force for the diagnosis and treatment of acute and chronic heart failure of the European Society of Cardiology (ESC). Developed with the special contribution of the Heart Failure Association (HFA) of the ESC. *European journal of heart failure*. 2016;**18**(8):891-975.
6. Pellman J, Sheikh F. Atrial fibrillation: mechanisms, therapeutics, and future directions. *Comprehensive Physiology*. 2011;**5**(2):649-65.
7. American Diabetes A. Diagnosis and classification of diabetes mellitus. *Diabetes care*. 2014;**37 Suppl 1**:S81-90.
8. Hypertension EETFftMoA. 2013 Practice guidelines for the management of arterial hypertension of the European Society of Hypertension (ESH) and the European Society of Cardiology (ESC): ESH/ESC Task Force for the Management of Arterial Hypertension. *Journal of hypertension*. 2013;**31**(10):1925-38.
9. Parmar MS. Family history of coronary artery disease--need to focus on proper definition! *European heart journal*. 2003;**24**(22):2073.
10. Arnett DK, Jacobs DR, Jr., Luepker RV, Blackburn H, Armstrong C, Claas SA. Twenty-year trends in serum cholesterol, hypercholesterolemia, and cholesterol medication use: the Minnesota Heart Survey, 1980-1982 to 2000-2002. *Circulation*. 2005;**112**(25):3884-91.
11. Morici N, De Servi S, Toso A, Murena E, Tamburrini P, Antonicelli R*, et al.* Renal function estimation and one-year mortality in elderly patients with non-ST-segment elevation acute coronary syndromes. *International journal of cardiology*. 2014;**174**(1):127-8.
12. Wettersten N, Maisel A. Role of Cardiac Troponin Levels in Acute Heart Failure. *Cardiac failure review*. 2015;**1**(2):102-6.
13. Lang RM, Badano LP, Mor-Avi V, Afilalo J, Armstrong A, Ernande L*, et al.* Recommendations for cardiac chamber quantification by echocardiography in adults: an update from the American Society of Echocardiography and the European Association of Cardiovascular Imaging. *European heart journal cardiovascular Imaging*. 2015;**16**(3):233-70.
14. Nagueh SF, Smiseth OA, Appleton CP, Byrd BF, 3rd, Dokainish H, Edvardsen T*, et al.* Recommendations for the Evaluation of Left Ventricular Diastolic Function by Echocardiography: An Update from the American Society of Echocardiography and the European Association of Cardiovascular Imaging. *European heart journal cardiovascular Imaging*. 2016;**17**(12):1321-60.
15. Zoghbi WA, Adams D, Bonow RO, Enriquez-Sarano M, Foster E, Grayburn PA*, et al.* Recommendations for Noninvasive Evaluation of Native Valvular Regurgitation: A Report from the American Society of Echocardiography Developed in Collaboration with the Society for Cardiovascular Magnetic Resonance. *Journal of the American Society of Echocardiography : official publication of the American Society of Echocardiography*. 2017;**30**(4):303-71.
16. Rudski LG, Lai WW, Afilalo J, Hua L, Handschumacher MD, Chandrasekaran K*, et al.* Guidelines for the echocardiographic assessment of the right heart in adults: a report from the American Society of Echocardiography endorsed by the European Association of Echocardiography, a registered branch of the European Society of Cardiology, and the Canadian Society of Echocardiography. *Journal of the American Society of Echocardiography : official publication of the American Society of Echocardiography*. 2010;**23**(7):685-713; quiz 86-8.
17. Wasywich CA, Pope AJ, Somaratne J, Poppe KK, Whalley GA, Doughty RN. Atrial fibrillation and the risk of death in patients with heart failure: a literature-based meta-analysis. *Internal medicine journal*. 2010;**40**(5):347-56.
18. Clavel-Ruipérez FG, Consuegra-Sánchez L, Redondo FJF, Mera LL, Mellado-Delgado P, Martínez-Díaz JJ*, et al.* Mortality and Atrial Fibrillation in the FIACA Study: Evidence of a Differential Effect According to Admission Diagnosis. *Revista Española de Cardiología (English Edition)*. 2018;**71**(3):155-61.
19. Damman K, Valente MA, Voors AA, O'Connor CM, van Veldhuisen DJ, Hillege HL. Renal impairment, worsening renal function, and outcome in patients with heart failure: an updated meta-analysis. *European heart journal*. 2014;**35**(7):455-69.

20. Tan ESJ, Tay WT, Teng TK, Sim D, Leong KTG, Yeo PSD*, et al.* Ethnic differences in atrial fibrillation in patients with heart failure from Asia-Pacific. *Heart*. 2019;**105**(11):842-7.
21. Gulsin GS, Kanagala P, Chan DCS, Cheng ASH, Athithan L, Graham-Brown MPM*, et al.* Differential left ventricular and left atrial remodelling in heart failure with preserved ejection fraction patients with and without diabetes. *Therapeutic advances in endocrinology and metabolism*. 2019;**10**:2042018819861593.
22. Damy T, Kallvikbacka-Bennett A, Goode K, Khaleva O, Lewinter C, Hobkirk J*, et al.* Prevalence of, associations with, and prognostic value of tricuspid annular plane systolic excursion (TAPSE) among out-patients referred for the evaluation of heart failure. *Journal of cardiac failure*. 2012;**18**(3):216-25.
23. Rossi A, Dini FL, Faggiano P, Agricola E, Cicoira M, Frattini S*, et al.* Independent prognostic value of functional mitral regurgitation in patients with heart failure. A quantitative analysis of 1256 patients with ischaemic and non-ischaemic dilated cardiomyopathy. *Heart*. 2011;**97**(20):1675-80.