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Association between echocardiographic markers of pulmonary hypertension and short-term prognoses in patients with acute heart failure

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***Abstract*---**Introduction: The prognostic value of pulmonary hypertension (PH) estimated by echocardiography in patients with acute decompensated heart failure (ADHF) is poorly studied. This study aimed to evaluate the association between echocardiographic markers of pulmonary hypertension and short-term prognoses in patients with AHF. Materials and Methods: This prospective cross-sectional study was conducted on patients with acute heart failure admitted to Golestan and Imam Khomeini hospitals in Ahvaz, Iran, in 2020. A total of 259 consecutive patients with ADHF underwent an echocardiographic evaluation to assess the probability of PH and right ventricular dysfunction (TAPSE<16 mm). The patients were followed up for six months after hospital discharge, and their outcome was recorded. The probability of PH was estimated based on European Society of Cardiology (ESC) guidelines for echocardiographic evaluation. Kaplan-Meier method was used to determine the cumulative survival rate and the Cox regression model to define the hazard ratio. Results: During six months of follow-up, the all-cause mortality rate was 118 (45.55%), including 106 cardiovascular deaths (40.92%). In multivariate Cox analysis, the hazard ratio (HR) for readmission to hospital, all-cause mortality, and cardiovascular mortality in patients with a high probability of PH was 1.320 (CI 95%: 1.122–1.516, P=0.001), 4.248 (CI95%: 2.875–6.277, P<0.0001) and 1.440 (CI95%: 1.691-0.280, P<0.0001) as compared to patients with a low or intermediate probability of PH. Lower age (HR: 0.983, P=0.013), smoking (HR:1.647, P=0.008), serum uric acid level (HR: 1.157, P<0.0001), presence of other PH symptoms on echocardiography (HR:2.267, P=0.051), RV size (HR: 1.709, P=0.026) were other independent factors for cardiovascular death. The left ventricular ejection fraction (HR: 1.606, P=0.095) and proper ventricular function were not associated with the adverse outcome (HR: 0.979, P=0.285). Conclusion: Our study shows that in ADHF patients with reduced LVEF, a high probability of PH as evaluated by echocardiography is a critical, independent prognostic feature to predict short-term mortality, whereas LVEF and RVF were not associated with prognosis. Identifying patients at high risk of PH by non-invasive measurement provides important prognostic information that could lead to improved clinical outcomes.

Keywords*---Heart failure, Pulmonary hypertension, Echocardiography.*

Introduction

Heart failure (HF) is one of the most critical health problems worldwide. The clinical syndrome is characterized by signs and symptoms such as shortness of breath, crackles on lung auscultation, peripheral edema, decreasing cardiac output, and increasing intracardiac pressure at rest or under stress (1). The prevalence of HF is about 1-2% and increases to more than 10% in people over 70 years old (2). It is easy to classify AHF based on pathophysiology and choose the proper treatment for each disorder. Moreover, it can be diagnosed by echocardiography, percutaneous coronary intervention, etc. The degree of applicability of each AHF classification system varies. According to ESC guidelines, there are six classifications of acute heart failure (Figure 1) (3)(4). Many cases of AHF are preventable; therefore, more effort should be made to provide disease-modifying therapy before and during hospitalization for AHF. Since the prevalence of AHF increases with age, appropriate and timely drug interventions are essential to prevent the progression of the disease and improve cardiac function (5). Identifying heart failure patients at risk of mortality and morbidity is necessary. An acute coronary syndrome (ACS) is a precipitating factor in 42% of new HF patients. At the same time, in patients with recent chronic heart failure, non-adherence to drug treatment, valvular disorders, and infections are the primary triggers for uncompensated heart failure (6). Heart failure symptoms and signs usually appear suddenly or progress rapidly and require immediate hospitalization (7). Acute decompensated heart failure is one of the leading causes of hospitalization and mortality in patients over 65 years of age (8). Pulmonary hypertension (PH) is one of the complications of chronic heart failure (9). Pulmonary hypertension in heart failure patients is associated with a high risk of mortality and morbidity. Pulmonary hypertension associated with heart failure accounts for about 65 to 80% of all PH cases (10). Increased pulmonary blood pressure in patients with left ventricular systolic dysfunction predicts a high risk of mortality and morbidity (11). The predictive value of the proper ventricular function and pulmonary artery pressure (PAP) has been evaluated in HFrEF and chronic HFpEF. Still, diagnostic techniques are rarely available in the context of the standard management of ADHF patients (12). Also, the correct ventricular function is sensitive to afterload, and its diagnostic value may be closely related to PAP and PH (9). The probability of PH can be calculated based on the echocardiographic assessment of tricuspid valve peak systolic regurgitation velocity (TRV) and other signs of pulmonary hypertension, including evaluation of pulmonary artery indices and IVC and proper atrial indices (1). Also, recently, in a study on ADHF patients, it was reported that the assessment of PH by echocardiography in ADHF patients has a high predictive value for mortality and readmission. At the same time, LVEF and RVF were unrelated to disease prognosis (13). This project investigates the relationship between echocardiographic markers of pulmonary hypertension and short-term prognosis (6 months) in hospitalized acute heart failure (AHF) patients.

Materials and Methods

A prospective analysis of acute heart failure patients hospitalized in the present study is performed as part of an analytical epidemiological study. Based on a first type error of 0.05, 80% power, and 28.2% occurrence rate, a minimum sample size of 258 people was calculated. Inclusion criteria include patients with a cardiologist's definitive diagnosis of acute heart failure. Diagnosis of ADHF is based on the rapid onset of heart failure symptoms with the presence of structural or functional cardiac abnormalities - increased brain natriuretic peptide (BNP) level > 100 ng/L or pro-BNP level > 300 ng/L (13) - age over 18 years - At least six months of follow-up - Patient consent to participate in the study and exclusion criteria - Acute coronary syndromes with or without ST-segment elevation - Severe heart valve diseases requiring evaluation for surgery during hospitalization - History of pulmonary embolism and any other illness It is due to pulmonary hypertension (14). Heart failure (HF) is diagnosed based on cardiac symptoms (such as dyspnea, ankle swelling, and fatigue) that may also be accompanied by other symptoms (such as increased jugular vein pressure, pulmonary crackles, or peripheral edema). Essential characteristics of patients include age, gender, weight, BMI, smoking, complete medical records, presence of underlying disease (including hypertension, history of chronic obstructive pulmonary disease (COPD), diabetes, chronic kidney disease, and chronic anemia), functional and functional medications NYHA class was collected and recorded in the data collection checklist. After discharge from the hospital, the patients were followed up for six months. The short-term outcome during six months included mortality from any cause, cardiovascular mortality (caused by heart failure, ischemic heart disease, or stroke), and readmission to the hospital and recorded became. Standard two-dimensional transaortic echocardiography, Doppler echocardiographic examinations, characteristics of the right and left heart cavities were examined, and echocardiographic parameters including pulmonary blood pressure (PH), LVEF, and right ventricular dysfunction were examined and recorded. Heart failure was defined by a decrease in left ventricular ejection fraction as LVEF<40% (1). *Diagnosis* of PH was defined as mean pulmonary artery pressure (PAPm) ≥ 20 mmHg at rest measured by right heart catheterization (RHC) (15). The low probability of pulmonary hypertension was defined as PTRV≤2.84 m/s or not measurable and without other symptoms of PH in echocardiography. Moderate probability of pulmonary hypertension was defined as PTRV≤2.84 m/s with other signs of PH or PTRV 2.85-3.4 m/s without other signs of PH in echocardiography. *The high probability* of pulmonary hypertension was defined as PTRV 2.85-3.4 m/s with other signs of PH on echocardiography or PTRV >3.4 m/s (16). Also, the systolic displacement of the tricuspid lateral plane annular segment (TAPSE) was measured in M-mode tracing under 2D echo guidance. Normal proper ventricular function (RVF) is defined as TAPSE ≥ 16 mm and pulsed wave tissue Doppler velocity of the tricuspid valve (s') ≥ nine cm/s. Also, RVF is defined as usual if one of the TAPSE or s' items is less than the corresponding threshold, but the radial function is normal. Reduced RVF is defined as TAPSE <16 mm and s' <9 cm/s, or if either TAPSE or s' is above the respective threshold but the radial function is reduced (1). SPSS (SPSS Inc., Chicago, IL, U.S.A.) version 22 was used for statistical analysis. The significant level in the tests was considered 0.05.

Result

In this study, 259 acute heart failure patients with a mean and standard deviation of age 63.13 ± 14.68 years (range 19 to 92 years) participated, including 107 women (41.3%) and 152 men (58.7%). They were. Also, in this study, all patients had acute heart failure with reduced left ventricular ejection fraction (LVEF≤40%). In the present study, out of 259 heart failure patients during the 6-month follow-up period, the mortality rate for any cause was 118 (45.55%), of which 12 (4.63%) were due to non-cardiovascular reasons and 106 (92 40.0% died due to cardiovascular diseases, and 153 people (59.1%) did not have a cardiovascular accident (Table 1). The 6-month overall survival rate of acute heart failure patients was estimated to be 79.52 days on average (95% CI: 90.93 - 68.11) using the Kaplan-Meier method. The average 6-month cardiovascular survival rate of acute heart failure patients using the Kaplan-Meier method was

80.22 days (95% CI: 92.21 - 68.22). 27.36% of patients died in the same first hospitalization, 36.79% in the second hospitalization, 30.19% in subsequent hospitalizations, and 5.66% had cardiovascular death outside the hospital. The results of the independent t-test showed that the variables of AST, ALT, PASP, TAPSE, LVEF, TRV peak, duration of hospitalization, number of times of rehospitalization, and the interval to the first rehospitalization between two groups of patients with and without cardiovascular death during six months of follow-up in terms of It was statistically different (P<0.05). However, the patients of the two groups did not differ significantly in terms of gender, BMI, hemoglobin, sodium, creatinine, BUN, and bilirubin parameters (P<0.05). The chi-score test results show a statistically significant relationship between the two PTRV variables and the outcome of death, so the death rate is higher in people with a high probability of pulmonary hypertension compared to two groups with a low and moderate likelihood of pulmonary hypertension. The relationship between four PTRV peak groups with different variables is presented in (Table 2). As can be seen, serum creatinine, sodium, ALT, TAPSE, size and circumference of LV and RV, IVC diameter, in different groups, PTRV, Respiratory collapse, D Shape septum, PA diameter, RVODAT, EDPRV, and functional class It had a different meaning. Other variables, including BMI, AST levels, uric acid, and bilirubin, did not significantly differ between different PTRV groups (P<0.05). Based on the analysis of variance, the time interval until the first rehospitalization showed a significant difference between the four PTRV groups (P<0.0001). As can be seen, among the investigated variables, only smoking and Peak TRV were influential factors in the rehospitalization of patients. The risk ratio of readmission for smokers compared to non-smokers was 2.188 (CI95%: 1.276 - 3.753; P=0.004). Also, the risk ratio of rehospitalization in patients with a high probability of pulmonary hypertension was 1.304 more than in patients with a low or moderate chance of PH (CI95%: 1.516-1.122; P=0.001). Cox regression analysis showed that the hazard ratio (HR) for all-cause mortality in patients with a high probability of pulmonary hypertension was 4.248 times higher (CI95%: 2.875-6.277, P<0.0001) than in patients with a high chance of pulmonary hypertension. The pH was low or medium. Also, the risk ratio of mortality from any cause for people with underlying disease compared to people without underlying disease was 0.508 (CI95%: 0.341-0.756; P=0.001). The risk ratio of death for smokers compared to non-smokers was 2.148 (95% CI: 1.378 - 3.347; P=0.001). Cox regression analysis showed that the hazard ratio (HR) for cardiovascular mortality in patients with a high probability of pulmonary hypertension was 1.440 times higher (CI95%: 0.280-1.691, P<0.0001) than in patients with a low likelihood or The pH was average. Also, increasing one age unit reduces the relative risk of cardiovascular death by 0.983 (it has a protective effect). The relative risk of death in the smoking group is 1.647 times that of the non-smoking group (reference). In the case of the uric acid variable, with an increase of 1 unit of uric acid, the occurrence of cardiovascular death increases by 1.157.

Discussion:

The present study showed that patients with acute heart failure who died due to cardiovascular diseases during six months of follow-up had higher AST, ALT, and uric acid levels, lower TAPSE and LVEF, and peak TRV compared to patients without this event. Taller, longer duration of hospitalization, more number of readmissions, shorter interval to the first readmission, and younger age. In a side study, et al. conducted a retrospective study to investigate the value of laboratory parameters for predicting in-hospital outcomes of acute heart failure patients. In AHF patients, lower LVEF and higher uric acid levels were among the laboratory parameters predicting adverse in-hospital complications (including mortality and emergency heart transplantation) (17). Echocardiography in patients with acute heart failure.

The predictive value of PH indices and RV dysfunction in patients with chronic heart failure is known (18). Also, it has recently been said that using these two markers together is more valuable than using them separately (11). The predictive value of evaluating the possibility of PH in echocardiography in ADHF patients has not been well studied. Therefore, the management guidelines for patients with uncompensated acute heart failure do not recommend routine echocardiography in these patients (19). In a study on 122 ADHF patients, reduced left ventricular ejection fraction (LVEF<40%) and RV end-diastolic diameter were reported as independent predictors of cardiovascular death (20). Another study of 326 consecutive ADHF patients with or without preserved LV ejection fraction reported an association between PH and RV dysfunction and higher 1-year mortality(21). Studies have been conducted in specific populations, including patients with idiopathic dilated cardiomyopathy, and have often evaluated heart transplantation or invasive right heart catheterization (22). Also, a study on selected ADHF patients with a previous history of advanced HF reported that PH is not a predictor of cardiac events in the short term (23). A combined effect of RVF and PAP on the risk of heart failure was reported in a cohort study, but the predictive value of PAP was not evaluated (12). The effects of RVF in chronic systolic heart failure have also been reported in a retrospective cohort study (16). Therefore, the results of these studies are inconsistent, and several factors (including heart failure with reduced or preserved LVEF, previous history of heart failure, and differences in RV function evaluation parameters in different studies) make direct comparisons impossible. Left valvular diseases also often lead to PH, albeit with changes in pulmonary vascular responses, and PH is an important prognostic factor in these patients (24). However, due to the invasive nature of catheterization and the high number of HF patients and hospitalization, this method of measuring pH is impractical in routine clinical care. . The present study showed that normal values obtained from echocardiography could well predict poor outcomes related to PH. Because mitral valve and aortic stenosis were associated with mortality from any cause in a study (13), patients with PH caused by other lung diseases or hypoxia were excluded from the present study in the present study. Recently, in a prospective study by Carballo and colleagues investigating the predictive value of possible pulmonary hypertension (PH) on echocardiography in 657 patients with acute decompensated heart failure (ADHF), 450 events, including 185 deaths, occurred during a median follow-up of 15 months. . Multivariate analysis showed that the risk ratio for mortality from any cause or rehospitalization and cardiovascular mortality for patients with a high probability of pulmonary hypertension was 1.67 and 2.7 times higher, respectively, than for patients with a low or moderate probability of PH, but decreased ejection fraction. Left ventricular fraction (LVEF<40) and proper ventricular function (reduced RVF) were not related to the primary outcome of the patient (9). These results are in line with the present study's findings. They show that assessing the possibility of PH by echocardiography in ADHF patients provides the highest independepredictivetic value for mortality and readmission. In another study by Badagliacca and his colleagues examined the prognostic significance of pulmonary hypertension in echocardiography and right ventricular dysfunction (as TAPSE<17 mm) in 214 patients with chronic heart failure and LVEF, < 40%, 40 patients died in an average follow-up of 230 days. Moreover, 41 patients were re-hospitalized for HF. Multivariate analysis showed that LVEF, PASP at the time of discharge, and plasma creatinine level were independent predictors of a negative outcome (all-cause mortality and readmission). Still, right ventricular function did not affect the patient's prognosis (14). Some of these findings are not consistent with the present study. In the present study, the mean LVEF was 21.92 ± 8.26, while the study by Badagliacca and his colleagues was conducted on chronic heart failure patients, and the mean LVEF was 29 ± 8, and the follow-up period of the patients was 12 months.In the present study, although LVEF was significantly lower in patients with cardiovascular death, its prognostic role was not observed. In other studies, it has been reported that the predictive value of LVEF is not linear and is influenced by various intervening factors (25). Patients without RV dysfunction without PH were not at increased risk of mortality during one year of follow-up (9). These results show that the presence of PH with RV dysfunction provides important prognostic information for ADHF patients, which can help manage and evaluate ADHF patients.The results of a retrospective study by Dziewięcka et al. on 502 patients with dilated cardiomyopathy (DCM) also showed that patients with a high and moderate probability of pulmonary hypertension (TRV > 3.4 m/s and TRV 2.9-3.4 m/s) on echocardiography were at increased risk. All-cause mortality was associated with a median follow-up of 45 months, while mortality was much lower in the low-risk PH group (TRV<2.9 m/s). Therefore, a lower probability of PH was associated with a better prognosis for patients. In this study, one-fifth of DCT patients were at high risk of PH (26). These results are consistent with the findings of the present study. The present study also showed that patients with a higher risk of pulmonary hypertension than groups with a lower probability of pulmonary hypertension had TAPSE > 16 and PAP 25 to 40. The first and second groups of PTRV, compared to the third and fourth groups of PTRV in more Cases, had TAPSE ≤ 16 and PAP > 40. In addition, patients with a higher risk of pulmonary hypertension (PTRV above 3.4 or between 2.8 and 4.3 with other signs of PH in echocardiography) compared to cases with a low risk of pulmonary hypertension had normal LV and RV size and circumference. IVC diameter was higher than usual, Respiratory collapse was lower than average, presence of D Shape septum was higher than average, PA diameter was higher than usual, RVODAT was lower than average, EDPRV was higher than usual, and also functional class was higher. Also, the duration of hospitalization, the number of times of rehospitalization, and the time interval until the first rehospitalization showed a significant difference between the PTRV groups, so that the groups with higher PTRV have a longer duration of hospitalization, more times of rehospitalization, and The time interval to the first readmission was shorter. Other variables, including BMI, AST levels, uric acid, and bilirubin, did not show significant differences between different PTRV groups. Finally, although the cut-off values in PASP used to define PH using echocardiography are different in the existing articles, the exact definition of hemodynamics for PH is not based on the systolic pulmonary pressure calculated in echocardiography but based on the average value measured in the right heart catheterization (16). Nevertheless, the results of the present study are consistent with the findings of previous studies regarding the predictive value of PH assessment in echocardiography in heart failure patients. Indeed, our study was performed on ADHF patients with reduced LV function and a wide range of PASP values (32 to 98 mmHg). Also, the study design can explain relatively low values of PASP in a significant part of patients; Moreover, this study did not investigate the role of initial echocardiography evaluation in the hospital prognosis of patients. However, our purpose was to investigate the role of echocardiography markers in the possibility of pulmonary hypertension in the short-term prognosis of patients. The echocardiography evaluation was performed when the condition of the patients was somewhat stabilized compared to the time of referral. In the present study, to prevent this factor's effect on the results, echocardiography was performed for all patients on the first day of hospitalization, when the patients' conditions had improved and stabilized. This study showed that routine assessment of PH and its integration into the care of hospitalized patients with ADHF could improve risk assessment, especially in patients with a high probability of PH. Specific treatments for PH such as diuretics and monitoring this group of patients can be necessary. Nevertheless, although the predictive value of echocardiographic evaluation of pulmonary hypertension in patients with acute decompensated heart failure has been observed in the present study and some other studies, limited studies have been conducted in this field. The evaluation of pH by echocardiography systematically identifies patients at risk and determines the disease's prognosis, and management needs more studies.

Conclusion

The results of the present study showed that the high probability of PH assessed by echocardiography is a strong and independent predictor of adverse outcomes such as readmission, all-cause mortality, and cardiovascular death in patients with acute heart failure. Young age, smoking, serum uric acid, other signs of PH in echocardiography, and RV size were other independent predictors of cardiovascular death. At the same time, many echocardiographic parameters, including LVEF and TAPSE (right ventricular function), were unrelated to a negative outcome. These results show that identifying patients at high risk of PH by non-invasive echocardiography provides important prognostic information. Therefore, evaluating the possibility of PH by echocardiography in acute heart failure patients can be used as an independent prognostic factor to manage and improve clinical outcomes in these patients.

Acknowledgment:

The research followed the tenets of the Declaration of Helsinki. The Ethics Committee of Jundishapur University of Medical Sciences approved this study. The institutional ethical committee at Jundishapur University of Medical Sciences approved all study protocols (IR.AJUMS.HGOLESTAN.REC.1400.064). Accordingly, written informed consent was taken from all participants before any intervention. This paper was extracted from the M.D thesis of Samira Kamali at the department of -------- at this university. Besides, the authors have observed

ethical issues (including plug and tourism, data fabrication, and double publication).

Competing interests:

The authors declare that they have no competing interests.

References

1. Savarese G, Lund LH. Global Public Health Burden of Heart Failure. Card Fail Rev [Internet]. 2017 [cited 2022 Jul 12];3(1):7. Available from: /pmc/articles/PMC5494150/
2. Kurmani S, Squire I. Acute Heart Failure: Definition, Classification and Epidemiology. Curr Heart Fail Rep [Internet]. 2017 Oct 1 [cited 2022 Jul 12];14(5):385–92. Available from: https://pubmed.ncbi.nlm.nih.gov/28785969/
3. Gupta AK, Tomasoni D, Sidhu K, Metra M, Ezekowitz JA. Evidence-Based Management of Acute Heart Failure. Can J Cardiol [Internet]. 2021 Apr 1 [cited 2022 Jul 12];37(4):621–31. Available from: https://pubmed.ncbi.nlm.nih.gov/33440229/
4. Alipour-Parsa S, Haybar H, Namazi MH, Safi M, Khaheshi I, Memaryan M, et al. Evaluation of pentraxin-3 level and its related factors in patients undergoing primary percutaneous coronary intervention. ARYA Atheroscler [Internet]. 2017 [cited 2022 Aug 11];13(2):73. Available from: /pmc/articles/PMC5628854/
5. Kamran H, Tang WHW. Medical management of acute heart failure. Fac Rev [Internet]. 2021 Dec 6 [cited 2022 Jul 12];10. Available from: /pmc/articles/PMC8725647/
6. Simpson J, Jackson CE, Haig C, Jhund PS, Tomaszewski M, Gardner RS, et al. Adherence to prescribed medications in patients with heart failure: insights from liquid chromatography–tandem mass spectrometry-based urine analysis. Eur Hear J — Cardiovasc Pharmacother [Internet]. 2021 Jul 1 [cited 2022 Jul 12];7(4):296. Available from: /pmc/articles/PMC8302254/
7. Marques-Alves P, Marinho AV, Almeida JP, Gonçalves T, Costa M, Ferreira M, et al. Real-world analysis of acute decompensated heart failure outcomes in Portugal. ESC Hear Fail [Internet]. 2020 Apr 1 [cited 2022 Jul 12];7(2):551–8. Available from: https://pubmed.ncbi.nlm.nih.gov/32022445/
8. Choi KH, Lee GY, Choi JO, Jeon ES, Lee HY, Cho HJ, et al. Outcomes of de novo and acute decompensated heart failure patients according to ejection fraction. Heart [Internet]. 2018 Mar 1 [cited 2022 Jul 12];104(6):525–32. Available from: https://pubmed.ncbi.nlm.nih.gov/28982721/
9. Macera F, Vachiéry JL. Management of Pulmonary Hypertension in Left Heart Disease. Methodist Debakey Cardiovasc J [Internet]. 2021 [cited 2022 Jul 12];17(2):115. Available from: /pmc/articles/PMC8298119/
10. Rao SD, Adusumalli S, Mazurek JA. Pulmonary Hypertension in Heart Failure Patients. Card Fail Rev [Internet]. 2020 Apr 9 [cited 2022 Jul 12];6. Available from: /pmc/articles/PMC7199161/
11. Sara JD, Toya T, Taher R, Lerman A, Gersh B, Anavekar NS. Asymptomatic Left Ventricle Systolic Dysfunction. Eur Cardiol Rev [Internet]. 2020 [cited 2022 Jul 12];15. Available from: /pmc/articles/PMC7199190/

12. Nochioka K, Querejeta Roca G, Claggett B, Biering-Sørensen T, Matsushita K, Hung CL, et al. Right Ventricular Function, Right Ventricular-Pulmonary Artery Coupling, and Heart Failure Risk in 4 US Communities: The Atherosclerosis Risk in Communities (ARIC) Study. JAMA Cardiol [Internet]. 2018 Oct 1 [cited 2022 Jul 12];3(10):939–48. Available from: https://pubmed.ncbi.nlm.nih.gov/30140848/
13. Carballo S, Musso P, Garin N, Müller H, Serratrice J, Mach F, et al. Prognostic Value of the Echocardiographic Probability of Pulmonary Hypertension in Patients with Acute Decompensated Heart Failure. J Clin Med [Internet]. 2019 Oct 1 [cited 2022 Jul 12];8(10). Available from: /pmc/articles/PMC6832915/
14. Badagliacca R, Ghio S, Correale M, Poscia R, Camporotondo R, Ferraretti A, et al. Prognostic significance of the echocardiographic estimate of pulmonary hypertension and of right ventricular dysfunction in acute decompensated heart failure. A pilot study in HFrEF patients. Int J Cardiol [Internet]. 2018 Nov 15 [cited 2022 Jul 12];271:301–5. Available from: https://pubmed.ncbi.nlm.nih.gov/30166068/
15. Libby P, Bonow R, Mann D, Tomaselli G, Bhatt D, Solomon S, et al. Braunwald's Heart Disease, Single Volume. 2021;2032.
16. Galiè N, Humbert M, Vachiery JL, Gibbs S, Lang I, Torbicki A, et al. 2015 ESC/ERS Guidelines for the diagnosis and treatment of pulmonary hypertension: The Joint Task Force for the Diagnosis and Treatment of Pulmonary Hypertension of the European Society of Cardiology (ESC) and the European Respiratory Society (ERS): Endorsed by: Association for European Paediatric and Congenital Cardiology (AEPC), International Society for Heart and Lung Transplantation (ISHLT). Eur Heart J [Internet]. 2016 Jan 1 [cited 2022 Jul 12];37(1):67–119. Available from: https://pubmed.ncbi.nlm.nih.gov/26320113/
17. Conis E. Polio, DDT, and Disease Risk in the United States after World War II. Environ Hist Durh N C [Internet]. 2017 Oct 1 [cited 2021 Jul 3];22(4):696–721. Available from: https://academic.oup.com/envhis/article/22/4/696/4057684
18. Ghio S, Guazzi M, Scardovi AB, Klersy C, Clemenza F, Carluccio E, et al. Different correlates but similar prognostic implications for right ventricular dysfunction in heart failure patients with reduced or preserved ejection fraction. Eur J Heart Fail [Internet]. 2017 Jul 1 [cited 2022 Jul 12];19(7):873–9. Available from: https://pubmed.ncbi.nlm.nih.gov/27860029/
19. Yancy CW, Jessup M, Bozkurt B, Butler J, Casey DE, Drazner MH, et al. 2013 ACCF/AHA guideline for the management of heart failure: Executive summary: A report of the American college of cardiology foundation/American Heart Association task force on practice guidelines. Circulation [Internet]. 2013 Oct 15 [cited 2022 Jul 12];128(16):1810–52. Available from: https://www.ahajournals.org/doi/abs/10.1161/cir.0b013e31829e8807
20. Maekawa E, Inomata T, Watanabe I, Yanagisawa T, Mizutani T, Shinagawa H, et al. Prognostic significance of right ventricular dimension on acute decompensation in chronic left-sided heart failure. Int Heart J [Internet]. 2011 [cited 2022 Jul 12];52(2):119–26. Available from: https://pubmed.ncbi.nlm.nih.gov/21483173/

21. Aronson D, Darawsha W, Atamna A, Kaplan M, Makhoul BF, Mutlak D, et al. Pulmonary hypertension, right ventricular function, and clinical outcome in acute decompensated heart failure. J Card Fail [Internet]. 2013 Oct [cited 2022 Jul 12];19(10):665–71. Available from: https://pubmed.ncbi.nlm.nih.gov/24125104/
22. Palazzini M, Dardi F, Manes A, Bacchi Reggiani ML, Gotti E, Rinaldi A, et al. Pulmonary hypertension due to left heart disease: analysis of survival according to the haemodynamic classification of the 2015 ESC/ERS guidelines and insights for future changes. Eur J Heart Fail [Internet]. 2018 Feb 1 [cited 2022 Jul 12];20(2):248–55. Available from: https://pubmed.ncbi.nlm.nih.gov/28464427/
23. Frea S, Pidello S, Bovolo V, Iacovino C, Franco E, Pinneri F, et al. Prognostic incremental role of right ventricular function in acute decompensation of advanced chronic heart failure. Eur J Heart Fail [Internet]. 2016 May 1 [cited 2022 Jul 12];18(5):564–72. Available from: https://pubmed.ncbi.nlm.nih.gov/26991036/
24. Fang JC, Demarco T, Givertz MM, Borlaug BA, Lewis GD, Rame JE, et al. World Health Organization Pulmonary Hypertension group 2: pulmonary hypertension due to left heart disease in the adult--a summary statement from the Pulmonary Hypertension Council of the International Society for Heart and Lung Transplantation. J Heart Lung Transplant [Internet]. 2012 Sep [cited 2022 Jul 13];31(9):913–33. Available from: https://pubmed.ncbi.nlm.nih.gov/22884380/
25. Owan TE, Hodge DO, Herges RM, Jacobsen SJ, Roger VL, Redfield MM. Trends in prevalence and outcome of heart failure with preserved ejection fraction. N Engl J Med [Internet]. 2006 Jul 20 [cited 2022 Jul 13];355(3):251–9. Available from: https://pubmed.ncbi.nlm.nih.gov/16855265/
26. Dziewięcka E, Wiśniowska-śmiałek S, Karabinowska A, Holcman K, Gliniak M, Winiarczyk M, et al. Relationships between Pulmonary Hypertension Risk, Clinical Profiles, and Outcomes in Dilated Cardiomyopathy. J Clin Med [Internet]. 2020 Jun 1 [cited 2022 Jul 13];9(6). Available from: https://pubmed.ncbi.nlm.nih.gov/32492830/

Figure 1: Classification of acute heart failure and clinical characteristics

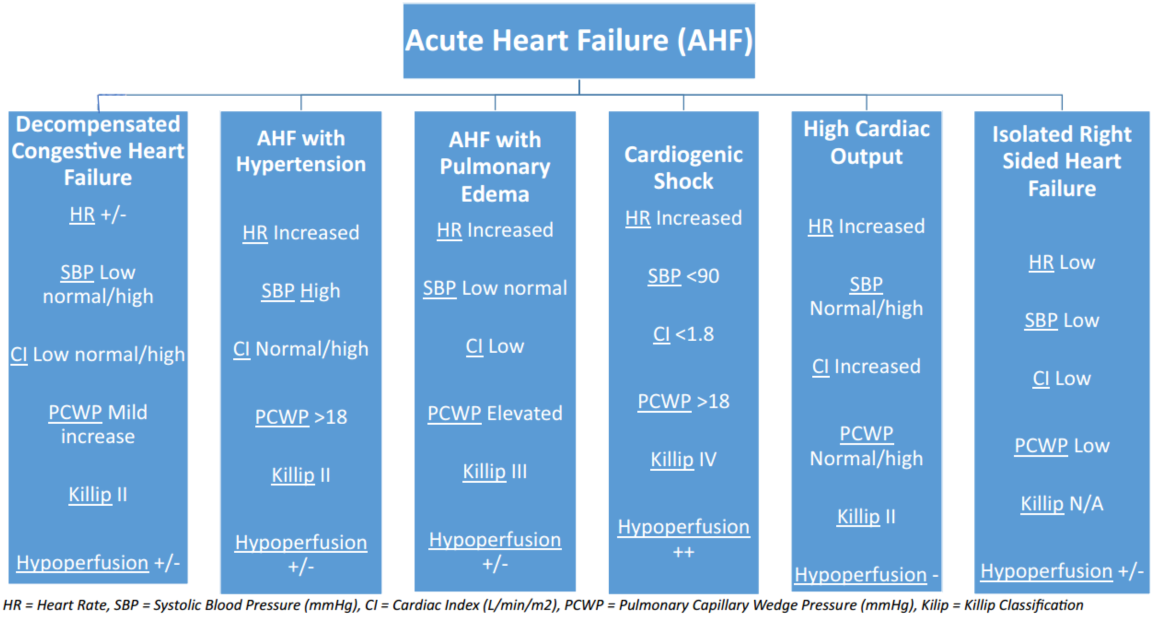

Table 1: Comparison of the frequency of cardiovascular death based on different variables

variable	number	No	Yes	P value
Gender	Woman (107)	39 (36.4)	68 (63.6)	0.238
	Man (152)	67 (44.1)	85 (55.9)	
Background disease	No (63)	38 (60.3)	25 (39.7)	0.001
	Yes (196)	68 (34.7)	128 (65.3)	
smoke	No (218)	80 (36.7)	138 (63.3)	0.001
	Yes (41)	26 (63.4)	15 (36.6)	
Functional class	1&2 (21)	6 (28.6)	15 (71.4)	0.012
	3 (160)	61 (38.1)	99 (61.9)	
	4 (78)	39 (50.0)	39 (50.0)	

Table 2: Relationship between four PTRV groups with different variables

variable	PTRV (m/s)	<2.8	2.8 – 3.4 no	2.8 – 3.4 yes	>3.4	P value
BMI (kg/m^2)	<20	0 (0)	4 (10.3)	18 (46.2)	17 (43.6)	0.591
	20-25	6 (4.7)	25 (19.4)	55 (19.4)	43 (33.3)	
	25-30	2 (2.8)	13 (18.3)	35 (49.3)	21 (29.6)	
	30≤	2 (10.0)	3 (15.0)	9 (45.0)	6 (30.0)	
Cr (mg/dL)	≤ 1.5	8 (6.0)	30 (22.6)	59 (44.4)	36 (27.1)	0.012

	1.5<	2 (1.6)	15 (11.9)	58 (46.0)	51 (54.8)	
Na (mEq/L)	<135	1 (1.1)	10 (10.8)	31 (33.3)	51 (54.8)	0.0001
	135-145	9 (5.6)	35 (21.6)	83 (51.2)	35 (21.6)	
	145<	0 (0)	0 (0)	3 (75.0)	1 (25.0)	
AST (U/L)	≤40	7 (6.1)	21 (18.3)	56 (48.7)	31 (27.0)	0.110
	40<	3 (2.1)	24 (16.7)	61 (42.4)	56 (38.9)	
ALT (U/L)	≤40	8 (6.6)	26 (21.5)	53 (43.8)	34 (28.1)	0.032
	40<	2 (1.4)	19 (13.8)	64 (46.4)	53 (34.8)	
Uric acid (mg/dL)	≤7	7 (7.0)	30 (30.0)	56 (56.0)	7 (7.0)	<0.0001
	7<	3 (1.9)	15 (9.4)	61 (38.4)	80 (50.3)	
Total bilirubin (mg/dL)	≤1	6 (5.3)	21 (18.4)	49 (43.0)	38 (33.3)	
	1<	4 (2.8)	24 (16.6)	68 (36.9)	49 (33.8)	0.709
TAPSE (mm)	<16	2 (1.3)	15 (9.4)	70 (44.0)	72 (45.3)	<0.0001
	16≤	8 (80.0)	30 (30.0)	47 (47.0)	15 (15.0)	
PASP (mmHg)	25-40	8 (10.8)	30 (40.5)	35 (47.3)	1 (1.4)	<0.0001
	40<	2 (1.1)	15 (8.1)	82 (44.3)	86 (46.5)	
LV size	Enlarge	1 (2.4)	15 (35.7)	16 (38.1)	10 (23.8)	0.007
	Normal	9 (4.1)	30 (13.8)	101 (46.4)	77 (35.5)	
RV size	Enlarge	4 (4.5)	29 (32.6)	44 (49.4)	12 (13.5)	<0.0001
	Normal	6 (6.8)	16 (9.4)	73 (42.9)	75 (44.1)	
LA area	Enlarge	1 (2.4)	15 (35.7)	16 (38.1)	10 (23.8)	<0.0001
	Normal	9 (4.1)	30 (13.8)	101 (46.4)	77 (35.5)	
RA area	Enlarge	7 (6.9)	33 (32.4)	47 (46.1)	15 (14.7)	<0.0001
	Normal	3 (1.9)	12 (7.6)	70 (44.6)	72 (45.9)	
IVC diameter	Normal	7 (11.9)	45 (76.3)	0 (0)	7 (11.9)	<0.0001
	Enlarge	3 (1.5)	0(0)	117 (58.5)	80 (40.0)	
Respiratory collapse	Normal	7 (9.0)	45 (57.7)	15 (19.2)	11 (14.1)	<0.0001
	less	3 (1.7)	0 (0)	102 (56.4)	76 (42.0)	
D Shape septum	No	10 (6.3)	45 (28.1)	76 (47.5)	29 (18.1)	<0.0001
	Yes	0 (0)	0 (0)	41 (41.1)	58 (58.6)	
PA diameter	Normal	10 (7.5)	45 (33.8)	61 (45.9)	17 (12.8)	<0.0001
	Enlarge	0 (0)	0 (0)	56 (44.4)	70 (55.6)	
RVODAT	Normal	10 (6.9)	45 (31.0)	73 (50.3)	17 (11.7)	<0.0001
	less	0 (0)	0 (0)	44 (38.6)	70 (61.4)	
EDPRV	Normal	10 (6.9)	45 (31.0)	73 (50.3)	17 (11.7)	<0.0001
	Enlarge	0 (0)	0 (0)	44 (38.6)	70 (61.4)	
Functional class	Class 1-2	0(0)	11 (52.4)	8 (38.1)	2 (9.5)	<0.0001
	Class 3	8 (5.0)	30 (18.8)	76 (47.5)	46 (28.7)	
	Class 4	2 (2.6)	4 (5.1)	33 (42.3)	39 (50.0)	

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