

The Association between Hemodynamic Parameters and Para Clinical Findings with Mortality in Heart Failure

Abstract

The study subjects consisted of 120 patients who underwent right heart catheterization in our institution between March 2010 to April 2014. The results showed that there is a significant correlation between mortality and hemodynamic and paraclinical findings. With regards to the importance of heart failure as one of the most serious factors of mortality, finding the correlation between hemodynamic and paraclinical findings with mortality and morbidity of the patients can be helpful in application of therapeutic approaches. In the present study, we showed that there is a significant correlation between some hemodynamic and paraclinical findings with each other and with mortality that can be used as indices for mortality and morbidity of heart failure patients. But, more studies are needed for finding the correlation between hemodynamic and paraclinical patients with mortality and morbidity of heart failure patients.

Keywords: Heart failure; Mortality; Morbidity; Hemodynamic parameters; Para clinical findings

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Abbreviations: HF: Heart Failure; NYHA: New York Heart Association; BUN: Blood Urea Nitrogen; HDL: High Density Lipoprotein; LDL: Low Density Lipoprotein; VLDL: Very Low-Density Lipoprotein; ALT: Alanine Transaminase; AST: Aspartate Transaminase; ALK: Alkaline Phosphates; TG: Triglyceride; CPK: Creatine Phosphokinase; CKMB: Creatine Kinase-MB; FC: Function Class; EF: Ejection Friction; LVEF: Left Ventricular Ejection Fraction; BNP: *Brain Natriuretic Peptid*; TSH: Thyroid-Stimulating Hormone; SD: Standard Deviation; HR: Heart Rate; BP: Blood Pressure; S: Systolic; D: Diastolic; CVP: Central Venous Pressure; PAP: Pulmonary Artery Pressure; S: systolic; D: diastolic; PWCP: Pulmonary Capillary Wedge Pressure; PVR Pulmonary Vascular Resistance; SaO₂: Arterial Oxygen Saturation; PP: Pulse Pressure; HGB: Hemoglobin, SVR: *Systemic Vascular Resistance*; RVP: *Right Ventricular Pressure*; CO: Cardiac Output; CI: Cardiac Index; HCT: Hematocrit; MCHC: Mean Corpuscular Hemoglobin Concentration; MCV: Mean Corpuscular Volume; MCH: Mean Corpuscular Hemoglobin; RBC: Red Blood Count; WBC: White Blood Count; PLT: Platelet Count; PT: Prothrombin Time; INR: International Normalized Ratio; PTT: Partial Thromboplastin Time; ESR: Erythrocyte Sedimentation Rate; TBILI: Total Bilirubin; DBILI: Direct Bilirubin; TIBC: Total Iron Binding Capacity; LDH: *Lactate Dehydrogenase*; BS: *Blood Sugar*; F: *Fasting*; CRP: *C-Reactive Protein*

Introduction

Heart failure (HF) is a major public health problem, with a prevalence of more than 3500 cases per 100,000 people in Iran and more than 26 million worldwide [1,2]. HF is a disease with a bad prognosis and also its appearance commonly signals the final stage of numerous processes. Mortality is similar to that of the most frequent cancers, with <50% 4-year survival [3,4]. Despite this, present developments in therapy have brought enhanced

quality of life and also survival to heart failure individuals. Nevertheless, improved survival and the numerous co morbidities [5,6] are accompanied by further health conditions. Present research shows that substantial amount of heart failure patients die from procedures other than cardiac disease, in particular malignancies, respiratory problems and septicemias [7]. Although current therapeutic approaches to heart failure have improved prognosis, mortality remains high even though, therefore in this study we evaluate the relation between measured indices in right heart catheterization and paraclinical findings with mortality and morbidity of heart failure patients.

Materials and Methods

This cross-sectional study was conducted during 2010-2014. From patients with FC 2-4 EF<30%, NYHA, patients suffering from advanced heart failure and LVEF<30% were selected and para-clinical findings including hemoglobin, sodium, potassium, pro BNP, TSH, T₄, T₃ Cr, BUN, Uric acid, HDL, and LDL levels were measured in this patients and after calculating hemodynamic and measuring paraclinical findings with 1month and then 2 months intervals, they were monitored for mortality rate and hospitalization and time to clinical worsening.

Results and Discussion

Results

120 patients including 80 male (66.67%) and 40 female (33.33%) with mean age of 38.28± 15.60 and mean height of 172±10 and mean weight of 70.85±16.19 were included to evaluate the correlation between measured indices in catheterization of right heart and paraclinical findings with mortality and morbidity of patients with chronic heart failure. 18 patients (14.9%) went under heart graft and 15 patients (12.4%) died. The interval

between referring time and heart graft was 87.09 ±80.05 days and the interval with the patient's mortality was 79.5±61.93 days.

Hemodynamic and paraclinical findings

Hemodynamic and paraclinical findings of the patients are shown in (Tables 1-4).

Table 1: Hemodynamic parameters.

Variable	Mean ± S.D	Variable	Mean ± S.D
Heart Rate (HR)	86.98 ± 15.29	Systemic Vascular Resistance (SVR)	19.29 ± 7.52
Systolic Blood Pressure (BP)	114.22 ± 20.29	Arterial Oxygen Saturation (SaO2)	93.17 ± 9.05
Diastolic Blood Pressure (BP)	71.81 ± 17.14	Systolic Right Ventricular Pressure (RVP)	60.09 ± 22.97
Central Venous Pressure (CVP)	14.34 ± 7.19	Diastolic Right Ventricular Pressure (RVP)	17.92 ± 7.65
Systolic Pulmonary Artery Pressure (PAP)	52.25 ± 28.85	Cardiac Output (CO)	4.42 ± 1.54
Diastolic Pulmonary Artery Pressure (PAP)	26.53 ± 12.37	Cardiac Index (CI)	2.44 ± 0.83
Pulmonary Capillary Wedge Pressure (PWCP)	26.11 ± 9.11	AORTA-Sat	90.40 ± 11.51
Pulmonary Vascular Resistance (PVR)	3.18 ± 3.27	Pulse Pressure (PP)	36.00 ± 13.41

HR: Heart Rate; BP: Blood Pressure; (S- Systolic; D- Diastolic); CVP: Central Venous Pressure; PAP: Diastolic Pulmonary Artery Pressure; (S- Systolic; D- Diastolic); PWCP: Pulmonary Capillary Wedge Pressure; PVR: Pulmonary Vascular Resistance; Sao2: Arterial Oxygen Saturation; PP: Pulse Pressure

The correlation between hemodynamic parameters and paraclinical findings

The results showed that there is a significant correlation between HR and paraclinical indices including Ca ,PH , CKMB, ALT, T4, and ESR, also, there is a significant correlation between hemodynamic findings (such as CO,CI,SBP and...) and some paraclinical findings (Table 5).

The correlation between laboratory findings with heart transplantation

The results showed that there is a direct correlation between heart graft and hemodynamic and paraclinical findings including CKMB, PP, Aorta Sat, TSH, FT4, FT3 and BS and also there was no significant correlation between heart graft and other evaluating findings.

Table 2: Complete blood count.

Variable	Mean ± S.D
Hemoglobin (Hgb) (g/dl)	12.57 ± 2.4
Hematocrit (Hct) (%)	37.71 ± 7.17
Mean Corpuscular Hemoglobin Concentration (MCHC) (g/dl)	32.25 ± 2.88
Mean corpuscular volume (MCV) (fl)	76.16 ± 21.43
Mean Corpuscular Hemoglobin (MCH) (pg)	27.78 ± 3.87
Red Blood Count (RBC) (Mil/μl)	4.63 ± 0.85
White Blood Count (WBC) (k/μl)	7.52 ± 2.59
Platelet count (PLT) (k/μl)	204.86 ± 80.10
Prothrombin Time (PT)	16.35 ± 5.18
International Normalized Ratio (INR)	1.35 ± 0.42
Partial Thromboplastin Time (PTT)	33.64 ± 7.90
Reticulocyte (%)	1.14 ± 0.41
Erythrocyte sedimentation rate (ESR) (mm/h)	11.10 ± 10.70

Hgb: Hemoglobin; SVR: Systemic Vascular Resistance; DRVP: Diastolic Right Ventricular Pressure; CO: Cardiac Output; CI: Cardiac Index; Hct: Hematocrit; MCHC: Mean Corpuscular Hemoglobin Concentration; MCV: Mean Corpuscular Volume; MCH: Mean Corpuscular Hemoglobin; RBC: Red Blood Count; WBC: White Blood Count; PLT: Platelet Count; PT: Prothrombin Time; INR: International Normalized Ratio; PTT: Partial Thromboplastin Time; ESR: Erythrocyte Sedimentation Rate

Correlation between hemodynamic findings and paraclinical findings with morbidity

During this study, the correlation of hemodynamic and paraclinical findings with mortality was evaluated. 39 patients (32.5%) were available from 120 patients. The results showed that the most frequent referring after 1 month was for 19 patients and the least referring after 12 months was 1 case. Also, there was a significant correlation between mortality and some hemodynamic and paraclinical findings (Table 6).

Correlation between hemodynamic and paraclinical findings with mortality

The results showed that there is a significant correlation between mortality and hemodynamic and paraclinical findings include CKMB, PP, Aorta Sat, CRP, HCo3, Pco2, PH and TIBC

Discussion

In the present study, 120 patients including 80 men (66.67%) and 40 women (33.33%) with mean age of 38.28±15.60 and mean height of 172±10 and mean weight of 70.85±16.19 were included to evaluate the correlation between measured indices in catheterization of right heart and paraclinical findings with mortality and morbidity of patients with chronic heart failure. 18

patients (14.9%) went under heart graft and 15 patients (12.4%) died. The interval between referring time and heart graft was 87.09 ± 80.05 days and the interval with the patient's mortality was 79.5 ± 61.93 days. This study was consistent with Ding et al. [8] for gender [8], but was not parallel with Sakatani et al. [8] in which the ratio of men to women was 1:1 [9]. In our study, there was no significant correlation between mortality and gender that was consistent with results of Sakatani et al. [8].

Table 3: Lipid profile, liver, kidney ad thyroid functional test.

Variable		Mean ± SD
Lipid profile	TG	92.04 ± 43.19
	Cholesterol	
	HDL	41.42 ± 24.93
	LDL	77.11 ± 21.63
	VLDL	14.41 ± 7.57
Liver parameter	ALT	27.38 ± 19.51
	AST	28.54 ± 13.21
	ALK	
	TBILI	1.57 ± 1.03
	DBILI	0.56 ± 0.54
	ALT	27.38 ± 19.51
Thyroid parameter	Free T3	2.95 ± 0.64
	Free T4	16.07 ± 2.72
	T3	1.16 ± 0.60
	T4	10.62 ± 2.60
	TSH	3.87 ± 5.58
Kidney parameter	BUN	24.36 ± 12.94
	Creatinine	1.01 ± 0.29
	Uric acid	7.10 ± 2.60
	CPK	67.74 ± 44.59

TG: Triglyceride; HDL: High-Density Lipoprotein; LDL: Low-Density Lipoprotein; VLDL: Very Low-Density Lipoprotein; ALT: Alanine Transaminase; AST: Aspartate Transaminase; ALK: Alkaline Phosphatase; TBILI: Total Bilirubin; DBILI: Direct Bilirubin; TSH: Thyroid-Stimulating Hormone; BUN: Blood Urea Nitrogen; CPK: Creatine Phosphokinase

Various studies have evaluated the relationship between hemodynamic indices and paraclinical findings and their correlation with mortality of the patients. In the present study, there was a significant correlation between tests relating to thyroid function including T3, T4 and TSH with some hemodynamic indices. The results showed that there is a significant correlation between T3 with SBP, CVP and DRVP and also between T4 and TSH with PVR and SVR and also TSH with DBP (Table 4). On the other hand, there was a significant correlation between graft surgery with serum levels of FT4, FT3 and TSH. Asvold et al. [10] indicated that there is a linear significant relationship between TSH with DBP and SBP [10] that these findings were consistent with ours. On the other hand, Danzi et al. [10] findings and Volzke

et al. [10] findings did not show any correlation between thyroid hormones and hypertension that were not parallel with our results [11,12]. Previous studies have shown that there is a correlation between serum levels of thyroid hormones with incidence of cardiovascular diseases, their prognosis and mortality of the patients [11,13]. Thyroid hormones lead to elevation of basal metabolic rate in most tissues that causes alteration in cardiac output and hemodynamic indices [14-16].

Table 4: Electrolyte, Iron, PH status and other serum test.

Variable	Mean ± SD	Variable	Mean ± SD
Ca	9.04 ± 1.02	Pco2	39.28 ± 7.18
P	3.98 ± 0.74	HCo3	26.57 ± 5.69
Na	3.99 ± 0.74	CKMB	17.33 ± 5.16
K	4.14 ± 0.47	LDH	1400 ± 540
Serum iron	66.00 ± 43.61	FBS	98.17 ± 32.79
Ferritin	179.88 ± 21.25	BS	141.14 ± 76.70
Mg	2.13 ± 0.62	Albumin	45.04 ± 21.21
TIBC	309.38 ± 112.80	CRP	13.50 ± 19.44
PH	7.39 ± 0.02	Pro-BNP	6938 ± 6236

TIBC: Total Iron Binding Capacity; CKMB: Creatine Kinase-MB; LDH: Lactate Dehydrogenase; BS: Blood Sugar; F: Fasting; CRP: C - Reactive Protein; BNP: Brain Natriuretic Peptid

Studies have shown that there is a relationship between lipid profile and mortality of heart failure patients and treatment of the patients with lipid lowering therapy decreases mortality and improves the patient's status. In our study, there was a significant correlation between serum levels of TG and VLDL with hemodynamic index of CVP, but there was no significant relationship between TC, LDL, HDL, TG and VLDL with mortality rate of the patients. These results were inconsistent with Ding et al. [8] results and results of Sakatani et al. [8] study, which showed significant correlation between TC, LDL, HDL and TG with mortality rate of the patients [8,9].

Studies have shown that there was a relationship between liver and kidney function with mortality rate of heart failure patients, and these disorders effect each other [17-20]. In the present study, the relation between liver and kidney function tests with hemodynamic indices and mortality rate of the patients was evaluated. The results showed that there is a significant correlation between liver and kidney function tests with some hemodynamic indices, but there is no significant relationship between these tests with mortality rate of the patients. Kawabe et al. [20] showed that there is a relationship between BUN levels and mortality rate [21]; also, Kearney et al. [21] showed that there is a direct correlation between high serum creatinine and mortality in heart failure patients [22]. These findings were not parallel with our results that might be due to the size of selected sample and severity of liver and kidney lesions.

The results of our study showed that there is a significant correlation between CBC and some hemodynamic indices (Table

1). Although there was no significant relationship between CBC and mortality of the patients, various studies showed that blood hemoglobin levels of patients and heart failure with their mortality [23]. Varadarajan et al. [23] showed that low Hb levels (< 12 gm/dl) is correlated with mortality of heart failure patient during 5 years and indicated that low Hb levels (< 12 gm/dl) can be used as an index in patient's mortality prediction [24]. Although there was no significant correlation seen between Hb and mortality in

our study, the reason might be due to normal level of Hb in the present study. Barron et al. [24] evaluated 153,213 patients and showed that WBC count is correlated with advancement of acute myocardial infarction (AMI) and increase of patient's mortality in long time [25]. Their results were inconsistent with our results which showed WBC count is not correlated with mortality that might be due to difference in sample volume and duration of patients following up.

Table 5: The correlation between hemodynamic parameters and paraclinical findings.

Hemodynamic Parameters	Paraclinical Parameters
(HR)	Ca (r: 0.396, P=0.007), PH(r: , CKMB (r: 0.976, P=0.001), ALT (r: 0.423, P= 0.001), T4 (r: -369, P= 0.041), ESR(r: -0.410, P=0.002)
(CO)	Ferritin (r:0.611, P=0.002), TBILI (r: -0.423, P=0.001), Hb(r: -0.236, P= 0.13), Hct (r:-0.301, P=0.003), RBC (r: -0.354, P=0.00), WBC(r:-0.294, P=0.002), INR (r:-0.301, P=0.003), PTT(r:-0.264, P=0.010), BUN (r: -0.243, P=0.011), Cr(r:-0.205, P= 0.33), Uric acid (r: -0.391, P=0.000), Hco3 (r: -0.577, P=0.049)
(CI)	Ferritin (r:0.611, P=0.002), TBILI (r: -0.423, P=0.001), Hb(r: -0.236, P= 0.13), Hct (r:-0.301, P=0.003), RBC (r: -0.354, P=0.00), WBC(r:-0.294, P=0.002), INR (r:-0.301, P=0.003), PTT(r:-0.264, P=0.010), BUN (r: -0.243, P=0.011), Cr(r:-0.205, P= 0.33), Uric acid (r: -0.391, P=0.000), Hco3 (r: -0.577, P=0.049)
(SBP)	Uric acid(r:-0.240, P=0.029), T3 (r:0.342, P= 0.019), P (r: -0.266, P= 0.042)
(DBP)	Na (r: 0.293, P=0.003), BUN (r: 0.223, P=0.029), TSH (r: -0.422, P= 0.005), MCHC (r: -0.214, P=0.036)
(CVP)	CKMB (r: 0.977, P=0.004), FBS(r:-0.243, P=0.031), BS (r: -0.844, P=0.001), BUN (r:0.255, P=0.029), TG(r:-0.380, P=0.003), VLDL(r: -0.424, P=0.001) , ALK (r: 0.294, P=0.013) , TBILI(r: 0.276, P=0.45), Uric acid, T3
(SPAP)	Ferritin (r:-0.476, P= 0.022), Hb (r:0.239, P=0.013), Hct (r: 0.251, P=0.013), RBC(r: 290, P=0.003), PT (r: 0.205, P=0.048)
(DPAP)	Ferritin(r: -0.534, P=0.011), TBILI (r: 0.285, P= 0.035), Uric acid (r: 0.255, P= 0.022), Hct (r: 0.207, P=0.48), RBC(r:0.230, P= 0.023), WBC (r: 0.257, P= 0.010), PT (r: 0.242, P=0.023), INR (r: 0.248, P=0.020)
(PVR)	T4 (r: -0.477, P=0.003), TSH (r: 0.345, P=0.039)
(SVR)	T4 (r: -0.516, P=0.010), TSH (r: 0.706, P= 0.00)
(DRVP)	P ,Na (r: 0.376, P=0.024), Serum Iron (r:0.832, P=0.002), TIBC (r: 0.754, P= 0.031), ALK (r: 0.504, P= 0.014), TBILI (r: 0.528, P=0.024), T3 (r: -0.423, P= 0.045), Hb (r: -0.361, P=0.024), RBC (r: -0.526, P=0.001), PLT (r: 0.418, P=0.012)
(O2-sat)	PH(r: 0.699, P=0.011)

HR: Heart Rate; CO: Cardiac Output; CI: Cardiac Index; BP: Blood Pressure; S: Systolic; D: Diastolic; CVP: Central Venous Pressure; PAP: Diastolic Pulmonary Artery Pressure; PVR: Pulmonary Vascular Resistance; SVR: Systemic Vascular Resistance; DRVP: Diastolic Right Ventricular Pressure; ALT: Alanine Transaminase; ESR: Erythrocyte Sedimentation Rate; BUN: Blood Urea Nitrogen; ALK: Alkaline Phosphatase; TG: Triglyceride; CKMB: Creatine Kinase-MB; TSH: Thyroid-Stimulating Hormone; Hb: Hemoglobin; Hct: Hematocrit; MCHC: Mean Corpuscular Hemoglobin Concentration; RBC: Red Blood Count; WBC: White Blood Count; PLT: Platelet Count; PT: Prothrombin Time; INR: International Normalized Ratio; PTT: Partial Thromboplastin Time; TBILI: Total Bilirubin; TIBC: Total Iron Binding Capacity; BS: Blood Sugar; F: Fasting

As shown in (Table 3), there is a significant correlation between serum levels of Ca, P, Na, Fe, Ferritin, TIBC, PH, CKMB, LDH, FBS, ALB and some hemodynamic indices. On the other hand, there was a correlation between heart graft in patients with CKMB, CRP, HCo3, PCO2, PH and TIBC. Also there was a significant correlation between mortality rate with CKMB and total protein. Aguilar et al. [25] in their study on diabetic patients reported a significant

relationship between HA1C and mortality, but mortality rate was decreased by control of the patient's glucose levels [26]. The reason of difference between this study and our study can be due to having normal ranges of glucose levels among the patients. Landesberg et al. [26] showed that there is a significant correlation between CKMB with mortality in heart failure patient's undergone surgery [27]. These results were parallel with ours. Hu

et al. [27] showed that very high levels of LDH have a direct and significant correlation with mortality in heart failure patients, and this difference might be due to not very high levels of LDH in evaluated patients in this study, on the other hand, in Hu et al. [27] there was a significant correlation between LDH with some hemodynamic indices such as PAP, CI, and PVR [28]. Kamioka

et al. [28] showed that there is a correlation between mortality and CRP, and also, CRP can be used as an index for cardiac re-synchronization therapy [29]. These findings were parallel with our findings which indicate that there is a significant correlation between heart graft and CRP, although they were not parallel in case of mortality.

Table 6: Correlation between hemodynamic findings and paraclinical findings with morbidity.

Date	Hemodynamic Para Clinical Parameters	Date	Hemodynamic Para Clinical Parameters
1 st month	PTT (r: 0.239, P=0.018), HDL (r:-0.304, P=0.011)	7 th month	-
2 nd month	WBC (r:-0.240, P=0.011), Hct (r: -0.206, P=0.037), CRP (r: -0.760, P=0.048), P (r:0.308, P=0.016)	8 th month	HDL (r: -0.339, P=0.004)
3 rd month	CRP (r: -0.760, P=0.048), P (r:0.300, P=0.019)	9 th month	-
4 th month	SRVP (r: -0.329, P=0.034), ESR (r: -0.277, P=0.014), PH (r: 0.588, P=0.035)	10 th month	BUN (r: -0.315, P=0.001)
5 th month	Reticulocyte (r: -0.760, P=0.048), CRP (r: -0.911, P=0.004)	11 th month	-
6 th month	-	12 th month	-

PTT: Partial Thromboplastin Time; HDL: High-Density Lipoprotein; WBC: White Blood Count; Hct: Hematocrit; CRP; C- Reactive Protein; SRVP: Systolic Right Ventricular Pressure; ESR: Erythrocyte Sedimentation Rate

In the present study, patients were evaluated in a one year interval study to determine the relationship between hemodynamic and para clinical findings with mortality. The results showed that the most frequent referring was after 1 month were 19 patients and the least referring after 12 months was a patient, also, no significant correlation was seen between mortality and some hemodynamic and paraclinical findings, but with regards to lacking of complete information about patients and their follow up, complete discussion is not effectual in this aspect.

Conclusion

With regards to the importance of heart failure as one of the most serious factors of mortality, finding the correlation between hemodynamic and paraclinical findings with mortality and morbidity of the patients can be helpful in application of therapeutic approaches. In the present study, we showed that there is a significant correlation between some hemodynamic and paraclinical findings with each other and with mortality that can be used as indices for mortality and morbidity of heart failure patients. Some limitations such as incomplete information of some patients and also short duration of following up, so more studies are needed for finding the correlation between hemodynamic and paraclinical patients with mortality and morbidity of heart failure patients.

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