Journal of Chemical Health Risks

www.jchr.org

JCHR (2024) 14(6), 17-25 | ISSN:2251-6727

Assessment of Outcome in Acute Heart Failure Patients with Degrees of Haemoconcentration at a Costal Rural Tertiary Care Hospital

[1]Dr. Kore Ramesh, [2]Dr. Chinnaiyan Ganeshan, [3]Dr. S. Arun Kumar, [4]Dr. Ramanathan Karuppiah,

[1]Junior Resident, Department Of General Medicine, Vinayaka Mission's Medical College And Hospital , Vinayaka Mission's Research Foundation,Karaikal.

[2]M.D., Professor, Department of General Medicine, Vinayaka Mission's Research Foundation,Karaikal

[3]M.D., Professor, Department of General Medicine, Vinayaka Mission's Research Foundation, Karaikal.

[4]M.D., Associate Professor, Department of General Medicine, Vinayaka Mission's Research Foundation,Karaikal.

(Received: 16 September 2024 Revised: 11 October 2024 Accepted: 04 November 2024)

KEYWORDS

Heart failure, Hemoconcentration, hemodilution,Framingham acute heart failure criteria.

ABSTRACT:

INTRODUCTION: Heart failure accounts for major cause of mortality and morbidity .Volume overload is one of the main reason for hospitalization in Acute Heart Faliure,hemoconcentration(increase in hemoglobin concentration) at discharge was proposed as good prognostic marker for survival. Therefore, the present study is conducted to evaluate the outcome of rural acute heart failure patients with degrees of haemoconcentration.

AIM AND OBJECTIVES: To assess the mortality of patients with Acute heart failure between various degrees of haemoconcentration and between Ejection fraction groups(HFrEF,HFmrEF,HFpEF).

MATERIALS AND METHODS: This is a cross sectional prospective observational study done on 66 patients admitted in a rural tertiary care hospital, Karaikal for a duration of 18 months.Patients aged above 18 years, those who are clinically diagnosed Acute heart failure according to the FRAMINGHAM ACUTE HEART FAILURE CRITERIA are included in the study.Patients who has CKD,<18 years,had blood transfusion and on Erythropoietin are excluded. Outcome:mortality with in 90 days post discharge.

RESULTS: P-value for comparison of hemoconcentration and hemodilution between expired and survived groups is 0.015(<0.05) which is statistically significant in between the groups.

INTRODUCTION: Heart failure (HF) is a medical condition characterized by a combination of symptoms and signs resulting from an abnormality in the structure and/or function of the heart. This diagnosis is supported by high levels of natriuretic peptides and/or proof of congestion in either the lungs or the body.(1)Heart failure accounts for one of the major cause of mortality. It was estimated that the annual incidence of heart failure ranges between 491600 to 1.8 million (2).World bank estimated cost of $108billion per annum attributed to heart failure management (3)Dealing with heart failure (HF) in India presents unique challenges due to its large population of over 1.4 billion, with an estimated 8-10 million HF patients (Conrad et al., 2020) (4). The prevalence is expected to rise due to increasing risk factors like diabetes, hypertension, and coronary artery disease, along with an aging population..

The main therapeutic goal in the management of acute heart failure is streamlining of fluid volumes (5) .Haemoconcentration is defined as the rise in the levels of haemoglobin concentration or haematocrit. Hence haemoconcentration can used as a guide for estimation of correcting volume status in patients with acute heart failure (6,7). During the treatment of AHF, hemodilution and hemoconcentration are part of a continuous spectrum. The mortality rates in these

Journal of Chemical Health Risks

www.jchr.org

JCHR (2024) 14(6), 17-25 | ISSN:2251-6727

subgroups were unknown because these degrees of hemoconcentration was excluded in previous research studies Therefore, the present study is conducted to evaluate the outcome of patients with various degrees of haemoconcentration.

AIM AND OBJECTIVES: To assess the outcome of patients with Acute heart faliure with degrees of haemoconcentration.

MATERIALS AND METHODS:

This is a cross sectional prospective observational study done on 66 IPD patients in a rural tertiary care hospital, Karaikal for a duration of 18 months.After getting Institutional Ethical Committee (IEC) approval and patients informed consent,Patients aged above 18 years, those who are clinically diagnosed Acute heart failure according to the FRAMINGHAM ACUTE HEART FAILURE CRITERIA are included in the study. Patients of age below 18 years, Patient presented with acute coronary syndrome, those who are on Chronic dialysis therapy, Use of erythropoietin and blood transfusion during hospitalisation were excluded from the study.

Study end point: Mortality within 90 days following discharge.

Approch for end point : status of the patient had been known over phone call through patients attenders or patients in out patient department (opd)

Data management: Based on the difference between discharge and admission hemoglobin levels was divided the patients into four categories –

Extreme haemodilution group ΔHg b ≤ -0.9

Modest haemodilution group (-0.8 ≤ΔHgb≤0

Modest haemoconcentration group (ΔHgb ≤0.7)

Extreme haemoconcentration group (0.8 ≤ΔHgb)

statistical analysis- Data was filed in MS excel sheet and analysed utilizing SPSS software version 24

For distribution of means between groups unpaired t-test and for distribution of propositions pearson chi-square test is used.

RESULTS AND DISCUSSION:

Table 1:Distribution of patients into groups based on ΔHgb

	Total	Extreme haemodilution (ΔHgb≤ -0.9)	Modest haemodilution (-0.8 ≤ ΔHgb ≤ 0)	Modest haemoconcentration (0 < ΔHgb ≤ 0.7)	Extreme haemoconcentration (0.8 ≤ Hgb)
No. of patients	66	10	28	12	16
Percentage	100%	15.15%	42.42%	18.18%	24.25%

TABLE 2: Comparison of baseline characteristics among the groups

Baseline characteristics	Total (n=66)	Extreme haemodilution (n=10)	Modest haemodilution (n=28)	Modest haemoconcentration (n=12)	Extreme haemoconcentration (n=16)	p-value
Mean age	62.71±11.5	72.00±12.40	60.45±9.923	55.42±12.873	66.24±8.182	**0.00**

Journal of Chemical Health Risks

www.jchr.org

JCHR (2024) 14(6), 17-25 | ISSN:2251-6727

(in years)	23	1				**2**
Mean WBC Count	8144±4938	11707±8164	8415±3866	7398±4215	6111±3656	**0.034**
Diabetes	41 (62.12%)	7 (70%)	18(64.28%)	7 (58.3%)	9 (52.9%)	0.782
Hypertension	30 (45.6%)	5 (50%)	11 (39.2%)	4 (33.3%)	10 (58.8%)	0.529
CAD	20 (29.4%)	4 (40%)	10 (34.5%)	3 (25%)	3 (17.6%)	0.543
Heart surgery	4 (7.4%)	2 (20%)	1(3.5%)	0 (0%)	1 (5.9%)	0.339
Ejection fraction	37.45±16.65	40.6±12.83	38.51±18.5	37.50±18.02	33.78±14.94	0.73

Grading based on EF	Total deaths (n=12)	Extreme haemodilution (n=4)	Modest haemodilution (n=5)	Modest haemoconcentration (n=2)	Extreme haemoconcentration (n=1)	p-value
≤ 40% (HFrEF)	10(83.33%)	3 (75%)	4(80%)	2(100%)	1(100%)	0.2
41-49% (HFmrEF)	1(8.33%)	1(25%)	0	0	0	
50%(HFpEF)	1(8.33%)	0	1(20%)	0	0	

Table 3: Deaths and Ejection fraction among the groups

0ut of total 12 deaths Extreme hemodilution (n=4), Modest haemodilution (n=5), Modest haemoconcentration (n=2), Extreme haemoconcentration (n=1) accounting for (40%,17.85%,16.6%,6.25%)respectively.

In comparison with EF , ≤ 40% (HFrEF has 10 deaths (83.33%),

TABLE 4:Comparison of parameters among the expired and survival patients

Baseline characteristics	Expired patients (n=12)	Survived patients (n=54)	p-value
Mean age (in years)	64.5±10.25	62.44±11.97	0.594
Mean WBC Count	8232±7674	8100±4306	0.934
Diabetes	7 (58.3%)	34 (63.0%)	0.505
Hypertension	4 (33.3%)	26 (48.1%)	0.272

Journal of Chemical Health Risks
www.jchr.org
JCHR (2024) 14(6), 17-25 | ISSN:2251-6727

CAD	6 (50.0%)	14 (25.9%)	0.1
Heart surgery	2 (16.7%)	3 (5.6%)	0.221
Ejection fraction	32.16±13.31	40±15.78	0.116
Serum Sodium (mEq/l)	134.5±4.49	135.15±5.48	0.702
Serum potassium (mEq/l)	4.29±1.51	4.01±0.84	0.368
Serum chlorides (mEq/l)	98.78±4.17	100.44±4.65	0.261
ΔHgb	-0.567±0.91	0.149±0.89	**0.015**
Laboratory findings at admission			
Haemoglobin (g/dL)	11.97±1.82	11.91±2.06	0.927
Blood urea (mg/dl)	54.75±30.62	42.98±22.26	0.128
Serum Creatinine (mg/dl)	1.47±1.21	1.23±0.93	0.447
BUN (mg/dl)	25.55±14.29	19.6±10.23	0.096
Laboratory findings at discharge			
Haemoglobin (g/dL)	11.41±2.11	12.06±2.01	0.312
Blood urea (mg/dl)	70.99±54.85	44.55±21.51	**0.008**
Serum Creatinine (mg/dl)	1.92±1.81	1.17±0.93	0.043
BUN (mg/dl)	33.11±25.55	20.36±9.71	0.005

Figure 1: Comparison of laboratory findings among the study subjects based on mortality at the time of discharge.

In our study out of 66 patients, majority of patients 28 are were in modest haemodilution group (-0.8 ≤ ΔHgd ≤ 0) accounting for 42.42%,followed by 16 patients were present in extreme hemoconcentration group (0.8 ≤ΔHgb) accounting for 24.25%,12 patients with 18.18% are in in modest haemoconcentration group (0<ΔHgb ≤0.7),least being 10 patients in Extreme hemodilution group accounting 15.15% of the study population.(Table:1)

In a study of 66 patients, gender distribution showed 36 males (54.54%) and 30 females (45.45%). In the modest haemodilution group, there were 18 males and 10 females. The p-value for sex distribution among the study population was 0.318, indicating no statistical significance.

6.4 Based on distribution of baseline characteristics among the Groups(Table:2)

Age: The average age of the study subjects is 62.71+/-11.523 years. P-value for age distribution in between the group is **0.002** P-value (<0.05).

WBC count: The mean WBC count of the study population is 8144+/-4938cells/cu.mm, P-value of **0.034** indicates a significant variation in WBC counts across the groups potentially reflecting different degrees of inflammation or stress response associated with fluid balance states.(8)

Journal of Chemical Health Risks

www.jchr.org

JCHR (2024) 14(6), 17-25 | ISSN:2251-6727

Diabetes: diabetics account for 62.12% p-value for distribution of diabetes in between the groups is 0.782.
Hypertension: Hypertensives accounting for 45.6% of the study P-value for comparison of hypertension in between the groups is0.529(p value>0.05) which is statistically insignificant.
CAD:CAD is observed in 20 patients accounting for 29.4% of the study population. P-value based on distribution of CAD in between groups is 0.543(>0.05) which is statistically insignificant in between the groups.
Ejection fraction: The mean ejection fraction of study population is 37.45+/-16.65. P-value for ejection fraction in between the groups is 0.73(value>0.05). **Haobin Zhou** et al (9) study Mean is EF:48.6 ±12.3 (P=0.030).
Age,Wbc count has significant correlation between groups.

Diabetes,Hypertension,CAD,Ejection fraction,serum electrolytes have insignificant p values. **Comparison of laboratory findings among the groups at the time of discharge:**

Hemoglobin(p=0.083),Blood urea(p=0.233),Serum creatinine(p=0.476),

BUN(p=0.143),all are statistically insignificant between the groups

patients in the extreme haemodilution group vs extreme hemoconcentration have higher levels of blood urea (67.70 ±46.37 vs 49.68 ± 27.26) , serum creatinine (1.76 ±1.79 vs 1.31 ±0.70), and BUN (31.77 ±21.3 vs 23.13 ±12.62), BUN between these groups has significant p value < 0.05.(unpaired T test) indicating a possible correlation with poorer renal function or higher metabolic activity

Regarding ejection fraction (EF) distribution(Table:3)

- Normal EF (>50%) was observed in 20 patients (27.27%). Group-wise distribution was 2, 11, 4, and 3 patients.

- Mid-range EF (41%-49%) was observed in 2 patients (3.03%). Group-wise distribution was 1, 0, 1, and 0 patients.

- Reduced EF (<40%) was observed in 44 patients (66.66%). Group-wise distribution was 7, 17, 7, and 13 patients.

The findings showed no statistically significant differences between the groups (p = 0.2), indicating that EF is a critical factor in heart failure prognosis but may not significantly vary across different patient subgroups.

Comparison of parameters among the expired and survived patients:(Table:4)

Mean Age: The average age of the patients in expired group is 62.5±10.76 years and in survived group is 62.76±11.80 years. P-value is 0.594(>0.05). Mean age is 63.63 (±12.70)years in retrospective study done by **Zulastri, M.A.M.,** et al 2021 on AHF in relation with readmissions and hematocrit.(10)

Mean WBC Count: The mean WBC count of the patients in expired group is 8298±7074 cells/cu.mm and in survived group is 8103±4306 cells/cumm.P-value is 0.934(>0.05).

Diabetes:7 patients were diabetic in the expired group accounting for 58.3% of the group population and 34 patients were diabetic in survived group accounting for 63% of the group population. P-value is 0.505 (>0.05). In line with **Haobin Zhou** study p=0.433.(9)

Hypertension: In the expired group 4 patients were hypertensive accounting for 33.3% of the group population and 26 patients were hypertensive accounting 48.1% of the survival group population. P-value is 0.272 (>0.05).

Heart Surgery: Only 2 patients in expired group accounting for 16.7% and 3 patients in the survived group underwent heart surgery accounting for 5.6% of the study population. The P-value for heart surgery in between the groups is 0.221(>0.05)

Ejection fraction:The average Ejection fraction of the expired group is 32.16±13.31 and the survived group is 40±15.78.P-value is 0.116(>0.05) .The lower values of Ejection fraction in expired group explains grave prognosis in patients with reduced Ejection fraction.In our study 40% of mortality is seen in patients with reduced Ef.

Journal of Chemical Health Risks

www.jchr.org

JCHR (2024) 14(6), 17-25 | ISSN:2251-6727

6.6.7 :Serum electrolytes: The mean serum sodium levels in the expired group are 134.5±4.49 mEq/dl and of the survived group is 135.15±5.48mEq/dl.P-value 0.702 (>0.05).

The mean serum potassium levels in the expired group is 4.29±1.51 mEq/dl and survived group is 4.01±0.84mEq/dl.P- value 0.368 (>0.05) which is statistically insignificant in between the groups.Similar results were seen in **Haobin Zhou** study(p=0.479)(9).

The mean serum chloride levels in the expired group are 98.78±4.17mEq/dl and of the survived group is 100.44±4.65mEq/dl.P- is 0.261 (>0.05).
Lesser the value of serum chloride more severe is the heart failure wrose is the prognosis.(11)

6.6.8 : Haemo concentration
Change in hemoglobin concentration(Hgb) among expired patients is -0.567 ±0.91 and among survived patients is 0.149±0.89 with p value of **0.015** which is statistically significant in between the groups.This implies extreme hemodilution and moderate hemodilution has worse outcome where as moderate hemoconcentration and extreme hemoconcentration has good outcome(less mortality).

Lab findings at the time of Discharge:Blood Urea: The mean blood urea levels of the expired group is 70.99±54.85 mg/dl and the levels of the survived group is 44.55±21.51 mg/dl.P-value is **0.008**(<0.05) . **Serum Creatinine:**The mean serum creatinine expired group is 1.92±1.81 mg/dl and the mean levels of the survived group is 1.17±0.93 mg/dl.P-value is **0.043**(<0.05).**Blood Urea Nitrogen:**The mean BUN levels of the expired group is 33.11±25.55 mg/dl and survived group is 20.36±9.71 mg/dl.P-value for BUN levels is **0.005**(0.05) which is statistically significant in between the groups.**Aronson** et al 2004 studied the value of BUN in patients admitted for heart failure,showed increased mortality in AHF patients.(12)

Acute heart failure (AHF) is characterized by the abrupt onset of new or worsening symptoms of heart failure within a short period of time [13]. Patients who are hospitalized with AHF typically show signs of volume overload[14,15].

During physiological state, there is a interplay between the movement of fluid between compartments to maintain homeostasis.Various methods can be used to assess volume status, including clinical findings such as jvp, dyspnea, S3 sounds, and measurements from pulmonary artery catheterization (like pulmonary capillary wedge pressure, central venous pressure). However, these methods have limitations, as they are invasive, costly, time-intensive, and lack accuracy. Indirect methods, like measuring hematocrit, protein, and albumin levels, offer a more cost-effective and less time-consuming approach to evaluating haemoconcentration. In our study, we focused on changes in hemoglobin levels instead of hematocrit, as hemoglobin can be directly measured.(16)

In the current study it was found that modest and extreme hemoconcentration showed an improvement in survival compared to modest hemodilution and extreme hemodilution(40%,17.85%,16.6%,6.25%).

Testani et al. conducted a study to evaluate the effects of aggressive decongestion on renal function and survival in 336 patients with AHF showed that hemoconcentration, even at the cost of deranged renal function , showed better survival.It is important to note that in our analysis, during hospitalisation, among the groups, worsening renal failure is found in between extreme hemodilution in comparison with extreme hemoconcentration group.This result was consistent with Testani et al. study[6]Another study conducted by Zhou *et al.* [8], showed that increased HCT during discharge was related with a decreased risk of mortality compared to those who Has hemodilution, in HCT $p <$ 0.001. It was also discovered that there was no substantial difference in decreasing renal function between the two groups (p = 0.15).A study by Zulastri et al. (10), showed the change in Hematocrit and ejection fraction are strong predictors for readmission in AHF but it's a retrospective study.In our study reduced ejection fraction has more mortality 15% when compared to preserved EF 3.3%.In comparison between survived and expired group of Our research uncovered that there was a significant difference in the change of hemoglobin concentration (ΔHgb) between patients who expired (-0.567 ±0.91) and those who survived

Journal of Chemical Health Risks

www.jchr.org

JCHR (2024) 14(6), 17-25 | ISSN:2251-6727

(0.149±0.89), with a p-value of 0.015 indicating statistical significance. This suggests that extreme hemodilution and moderate hemodilution have worse outcomes compared to moderate hemoconcentration and extreme hemoconcentration. This finding resonates with a previous study by Carlos Davila et al, 2011, which examined hemoglobin levels upon admission and discharge in ADHF patients. Their research showed that hemoconcentration was linked to a lower risk of all-cause mortality in univariate analysis (hazard ratio 0.53, 95% CI 0.29-0.96, P =.035). However, in multivariate analysis, hemoconcentration was only associated with worsening renal function but not mortality.(17)Quian yan et al.postulated that Hemoconcentration, BNP, New York Heart Association (NYHA) cardiac function classification and serum creatinine were unlinked prognostic factors in AHF.Compared with that of BNP, measurement of the HCT is more expedient and economical and may be widely performed at primary hospitals.(18).Reduced Ef <40 %,Extreme hemodilution,and raised blood urea nitrogen,serum Creatinine, at discharge have a pivotal role in predicting mortality in acute heart failure patients.

CONCLUSION: Study indicates that moderate and severe hemoconcentration offer better prognostic insights compared to hemodilution even at the expense of worsening of renal function.Therefore, monitoring changes in hemoconcentration, a straightforward and easily accessible parameter, can be beneficial in medical settings for identifying patients at risk of negative outcomes. It also presents an enticing opportunity for improving therapeutic interventions.

LIMITATIONS: Small study sample, single tertiary care centre study not covering wide population. considering The diagnosis of ADHF was based on FRAMINGHAM CEITERIA which has less sensitivity when compared to natriuretic peptides in the diagnosis of AHF, dosage and information on diuretics has not taken into consideration.

ABBREVATIONS:CKD:Chronic kidney disease,ADHF:Acute Decompensated Heart Faliure,BNP:Brain Natriuretic Peptide.

REFERENCES:

1.Bozkurt, B., Coats, A. J. S., Tsutsui, H., Abdelhamid, C. M., Adamopoulos, S., Albert, N., Anker, S. D., Atherton, J., Böhm, M., Butler, J., Drazner, M. H., Michael Felker, G., Filippatos, G., Fiuzat, M., Fonarow, G. C., Gomez-Mesa, J. E., Heidenreich, P., Imamura, T., Jankowska, E. A., Januzzi, J., … Zieroth, S. (2021). Universal definition and classification of heart failure: a report of the Heart Failure Society of America, Heart Failure Association of the European Society of Cardiology, Japanese Heart Failure Society and Writing Committee of the Universal Definition of Heart Failure: Endorsed by the Canadian Heart Failure Society, Heart Failure Association of India, Cardiac Society of Australia and New Zealand, and Chinese Heart Failure Association. European journal of heart failure, 23(3), 352–380. https://doi.org/10.1002/ejhf.2115

2.Ambrosy, A. P., Fonarow, G. C., Butler, J., Chioncel, O., Greene, S. J., Vaduganathan, M., Nodari, S., Lam, C. S. P., Sato, N., Shah, A. N., & Gheorghiade, M. (2014). The global health and economic burden of hospitalizations for heart failure: lessons learned from hospitalized heart failure registries. Journal of the American College of Cardiology, 63(12), 1123–1133. https://doi.org/10.1016/j.jacc.2013.11.053

3.Cook, C., Cole, G., Asaria, P., Jabbour, R., & Francis, D. P. (2014). The annual global economic burden of heart failure. International journal of cardiology, 171(3), 368–376. https://doi.org/10.1016/j.ijcard.2013.12.028

4.Conrad, N., Judge, A., Tran, J., Mohseni, H., Hedgecott, D., Crespillo, A. P., Allison, M., Hemingway, H., Cleland, J. G., McMurray, J. J. V., & Rahimi, K. (2018). Temporal trends and patterns in heart failure incidence: a population-based study of 4 million individuals. Lancet (London, England), 391(10120), 572–580. https://doi.org/10.1016/S0140-6736(17)32520-5

5.Boorsma, E. M., Ter Maaten, J. M., Damman, K., Dinh, W., Gustafsson, F., Goldsmith, S., Burkhoff, D., Zannad, F., Udelson, J. E., & Voors, A. A. (2020). Congestion in heart failure: a contemporary look at physiology, diagnosis and

treatment. *Nature reviews. Cardiology*, *17*(10), 641–655. https://doi.org/10.1038/s41569-020-0379-7

6.Testani, J. M., Brisco, M. A., Chen, J., McCauley, B. D., Parikh, C. R., & Tang, W. H. (2013). Timing of hemoconcentration during treatment of acute decompensated heart failure and subsequent survival: importance of sustained decongestion. *Journal of the American College of Cardiology*, *62*(6), 516–524. https://doi.org/10.1016/j.jacc.2013.05.027

7.van der Meer, P., Postmus, D., Ponikowski, P., Cleland, J. G., O'Connor, C. M., Cotter, G., Metra, M., Davison, B. A., Givertz, M. M., Mansoor, G. A., Teerlink, J. R., Massie, B. M., Hillege, H. L., & Voors, A. A. (2013). The predictive value of short-term changes in hemoglobin concentration in patients presenting with acute decompensated heart failure. *Journal of the American College of Cardiology*, *61*(19), 1973–1981. https://doi.org/10.1016/j.jacc.2012.12.050

8.Vulesevic, B., Sirois, M. G., Allen, B. G., de Denus, S., & White, M. (2018). Subclinical Inflammation in Heart Failure: A Neutrophil Perspective. The Canadian journal of cardiology, 34(6), 717–725. https://doi.org/10.1016/j.cjca.2018.01.018

9.Zhou, H., Xu, T., Huang, Y., Zhan, Q., Huang, X., Zeng, Q., & Xu, D. (2017). The top tertile of hematocrit change during hospitalization is associated with lower risk of mortality in acute heart failure patients. BMC cardiovascular disorders, 17(1), 235. https://doi.org/10.1186/s12872-017-0669-0

10.Zulastri, M. A. M., Hafidz, M. I., Ismail, M. D., & Zuhdi, A. S. M. (2021). Hematocrit change as a predictor of readmission for decompensated heart failure: a retrospective single centre study. Reviews in cardiovascular medicine, 22(2), 505–512. https://doi.org/10.31083/j.rcm2202058

11.Cuthbert, J. J., Pellicori, P., Rigby, A., Pan, D., Kazmi, S., Shah, P., & Clark, A. L. (2018). Low serum chloride in patients with chronic heart failure: clinical associations and prognostic significance. European journal of heart failure, 20(10), 1426–1435. https://doi.org/10.1002/ejhf.1247

12. Aronson, D., Mittleman, M. A., & Burger, A. J. (2004). Elevated blood urea nitrogen level as a predictor of mortality in patients admitted for decompensated heart failure. The American journal of medicine, 116(7), 466–473. https://doi.org/10.1016/j.amjmed.2003.11.014

13 Ponikowski, P., Voors, A. A., Anker, S. D., Bueno, H., Cleland, J. G. F., Coats, A. J. S., Falk, V., González-Juanatey, J. R., Harjola, V. P., Jankowska, E. A., Jessup, M., Linde, C., Nihoyannopoulos, P., Parissis, J. T., Pieske, B., Riley, J. P., Rosano, G. M. C., Ruilope, L. M., Ruschitzka, F., Rutten, F. H., … ESC Scientific Document Group (2016). 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 heart journal, 37(27), 2129–2200. https://doi.org/10.1093/eurheartj/ehw128

14.Fonarow, G. C., Abraham, W. T., Albert, N. M., Gattis, W. A., Gheorghiade, M., Greenberg, B., O'Connor, C. M., Yancy, C. W., & Young, J. (2004). Organized Program to Initiate Lifesaving Treatment in Hospitalized Patients with Heart Failure (OPTIMIZE-HF): rationale and design. American heart journal, 148(1), 43–51. https://doi.org/10.1016/j.ahj.2004.03.004

15. Adams, K. F., Jr, Fonarow, G. C., Emerman, C. L., LeJemtel, T. H., Costanzo, M. R., Abraham, W. T., Berkowitz, R. L., Galvao, M., Horton, D. P., & ADHERE Scientific Advisory Committee and Investigators (2005). Characteristics and outcomes of patients hospitalized for heart failure in the United States: rationale, design, and preliminary observations from the first 100,000 cases in the Acute Decompensated Heart Failure National Registry (ADHERE). *American heart journal*, *149*(2), 209–216. https://doi.org/10.1016/j.ahj.2004.08.005

16. Voors, A. A., Dittrich, H. C., Massie, B. M., DeLucca, P., Mansoor, G. A., Metra, M., Cotter, G., Weatherley, B. D., Ponikowski, P., Teerlink, J. R., Cleland, J. G., O'Connor, C. M., & Givertz, M.

Journal of Chemical Health Risks

www.jchr.org

JCHR (2024) 14(6), 17-25 | ISSN:2251-6727

M. (2011). Effects of the adenosine A1 receptor antagonist rolofylline on renal function in patients with acute heart failure and renal dysfunction: results from PROTECT (Placebo-Controlled Randomized Study of the Selective Adenosine A1 Receptor Antagonist Rolofylline for Patients Hospitalized with Acute Decompensated Heart Failure and Volume Overload to Assess Treatment Effect on Congestion and Renal Function). Journal of the American College of Cardiology, 57(19), 1899–1907. https://doi.org/10.1016/j.jacc.2010.11.057

17. Davila, C., Reyentovich, A., & Katz, S. D. (2011). Clinical correlates of hemoconcentration during hospitalization for acute decompensated heart failure. *Journal of cardiac failure*, *17*(12), 1018–1022. https://doi.org/10.1016/j.cardfail.2011.08.004

18. Yan, Q., & Chen, S. (2020). Hemoconcentration is a valuable predictor of prognosis in patients with acute heart failure. *Experimental and therapeutic medicine*, *19*(4), 2792–2798. https://doi.org/10.3892/etm.2020.8515