JBAAR

Journal of Bioscience and Applied Research

https://jbaar.journals.ekb.eg

SPBH

Evaluation of Brain natriuretic peptide in premature heart contraction patients

NOOR Kasim Haider [(1)] *, Arshad Noori Al-Dujaili [(2)]

[1,2]University of Kufa / Faculty of Sciences, Najaf, Iraq

* Corresponding Author: Arshad.aldujaili@uokufa.edu.iq

DOI:10.21608/jbaar.2025.442333

Abstract

The current study was designed to study biomarkers premature atrial and ventricular contraction by using brain natriuretic peptide (BNP). The study was performed on patients' clinics and private laboratories in AL-Najaf Governorate / Iraq from August 15\8\2024, to January 15\1\2025.

The total number was ninety (90) participants, including sixty (60) patients with premature heart contractions and thirty (30) was the healthy control group. Patients were subdivided into several subdivisions according to age, type of premature heart contraction (atrial and ventricular), diagnosis (treated or new diagnosis), duration of disease, hypertension, and body mass index group. The present results revealed a signification increase ($P<0.05$) in brain natriuretic peptide in patients compared with the control group. Male patients significantly increase ($P<0.05$) than female patients. The current results also indicate that older age, 60-69 years, was significantly increased ($P<0.05$) in comparison with ventricular patients. A new diagnosis in patients was a highly significant increase ($P<0.05$) than treated patients. The present study also indicated that the hypertensive patient group showed a highly significant increase ($P<0.05$) than the normotensive group. Duration of diseases (1 weak-1 month) in patients' groups was highly significant ($P<0.05$) than (1-5) years and >5 years.

According to body mass index obese patients' group was significantly higher ($P<0.05$) than the overweight and normal weight groups. The present study concluded that brain natriuretic peptide was a new biomarker in both atrial and ventricular premature contraction and can be used for diagnosing or predicting this disease to prevent any future complications.

Keywords: Premature atrial contraction, sex, age, atrial

Introduction

Premature atrial and ventricular contraction is defined as an extra beat that starts in the upper chamber of the heart, like the heart skips beats in both atria and ventricles, and occurs from an area different from the sinus node that leads to an interruption of the heartbeat rhythm (1,2).

Natriuretic peptide (NP), a member of polypeptide hormones secreted by myocardial cells, plays important roles in the regulation of heart volume, homeostasis of the cardiovascular system. Therefore, two types of NP can be distinguished: atrial natriuretic peptide (ANP) and brain natriuretic peptide (BNP). These two peptides are synthesized in both atrial and ventricular cardiomyocytes (3,4).

Several sites called extra-cardiac sites, including the brain, gonad, and kidney considered other sites of BNP synthesis (5,6). Many diseases associated with the heart lead to BNP elevation, such as ventricular dysfunction, atrial and ventricular fibrillation, also ischemic heart disease (7,8). Family of natriuretic peptides including four subtypes, early identified in bony fishes called itagfish such as ANP, BNP, C-natriuretic peptide (CNP), and ventricular natriuretic

Received: January 1, 2025. Accepted: March 1, 2025. Published: June 27, 2025

peptide (VNP) in addition Pro-BNP is a polypeptides consist of 108 amino acids encoded by genes located on chromosome 1 in which considered as precursor protein for BNP which consist of 32 amino acids at molecular weight 3472 Dalton (9-11). This study aims to study the biomarker to determine a new strategy for diagnosis, also predict an important disease called premature atrial and ventricular contraction by using brain natriuretic peptide.

Materials and Methods

Subjects

The present study included patients suffering from premature heart contraction a sixty (60), and control (apparently healthy) as thirty (30). Patient samples were collected from patients who are coming to Al-Najaf center for cardiovascular surgery and cardiac catheterization, and Private Laboratories in Al-Najaf Al-Ashraf Province from August 15\8\2024, to January 15\1\2025. Patients were divided into several subgroups according to Age, Sex, atrial or ventricular, diagnosis, duration of disease, hypertension, and body mass index.

Inclusion criteria

The current study includes patients suffering from atrial and ventricular premature contraction and different ages and both sexes and diagnosed as new or treated with different body mass index (normal, overweight, and obese), with hypertensive or normotensive status, and of different durations of disease.

Exclusion

Several criteria were excluded from the present study, such as heart failure and myocardial infarction, as well as other diseases such as kidney failure, liver disorder, diabetes mellitus, and hematological disease.

Collection of blood samples

Blood samples were collected from patients by plastic syringes and needles from arterial cubital vein puncture at 8:30 am and 5:00 pm, according to the different places were taken in the present study. After 3 mL of blood was drawn, left at room temperature for 10 minutes in a water bath to clot in gel tube to measure Insulin-like Growth Factor Binding Protein (IGFBP-1), and the remaining 2 mL was placed in an Ethylenediamine Tetra-acetic Acid (EDTA) tube for measuring Brain Natriuretic Peptides (BNP) in plasma. Serum was separated by centrifugation at 3000 for 15 minutes, and after isolation, the serum was transported to a disposable tube (Eppendorf tube) at stored at (-20 °C to_ -4 °C).

Diagnosis

Physician and visitation (doctor) diagnosis a patient according to Electrocardiographic to atrial and ventricles (Figure 3_1 and 3_2) with symptoms including pallor, difficulty breathing, general weakness, chest pain, difficulty in moving or walking.

Biomarkers assay

Brain natriuretic peptides (BNP)

Kits were supplied by Finecare, measuring by Finecare as catalog number (W825P0001)

Experimental design

The total number of patients, including sixty (60) and control thirty (30), was subdivided into several subgroups:

1-Atrial premature contraction patients as thirty (30), and ventricle premature thirty (30).

2-New and treated included new patients' subgroups as twenty-five (25), and treated subgroups, thirty-five (35).

3- Duration of disease (1 week-1 month) as twenty (20), (1-5 years) included twenty-five (25), and more than 5 years as fifteen (15).

4-Hypertensive subgroups included forty (40) and normotensive a twenty (20).

5-Body mass index included normal weight, twenty (20), overweight, fifteen (15), and obese, twenty-six (26).

6- According to sex, included males twenty-five (25) and females thirty-five (35).

7-According to age, included (30-39) years as fifteen (15), (40-49) years old as ten (10),(50-59) years old as twenty (20), and (60-69)

Statistical analysis

The data analysis was performed by SPSS version 20, where we used a t-test for independent groups between patients and controls, and a correlation analysis was performed in this study.

Results

Brain Natriuretic Peptides (BNP)

Comparison between premature heart contraction patients and the control group

Figure 1 indicates a significant increase ($p< 0.0001$) in premature heart contraction patients (467.7± 39.13) in comparison with the control group (31.38 ±2.699).

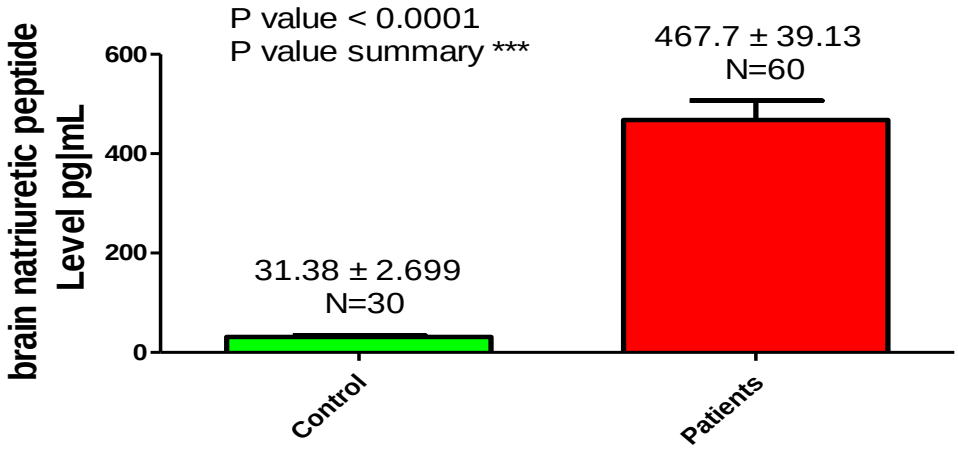

Figure 1: Brain natriuretic peptide Level in patients compared with the control group

Comparison between premature heart contraction patients in BNP level according to sex.

The present results in Figure 2 revealed a significant in ($P< 0.0001$) in male (753.9 4±9.25) in increase to female (263.2 ±19.56).

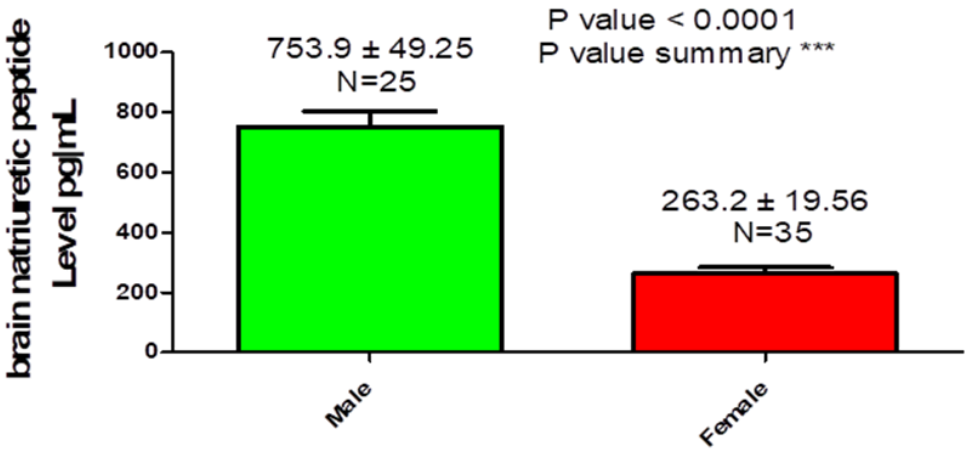

Figure 2: Brain natriuretic peptide Level in Male compared with Female patients

Comparison between premature heart contraction in BNP according to age.

The current study in Figure 3 indicates a signification increase (P < 0.0001) in ages (60-69) years (895.1 5 ±7.35) in comparison with age (50-59) years (476.4 ± 17.91),(40-49) years (280.8 ± 11.49) and (30-39) years (152.1 ± 6.877). Also, other age groups, 50-59 years, 40-49 years, showed significant increases with age (30-39) years.

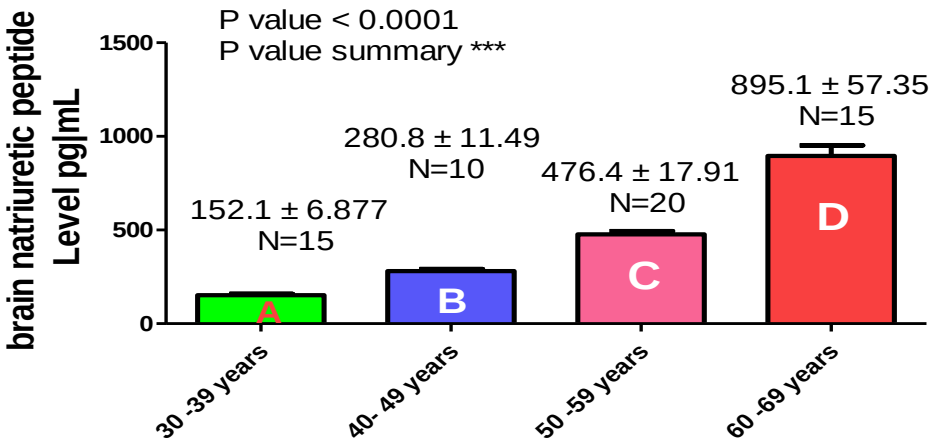

Figure 3: Brain natriuretic peptide Level in different age patients.

Comparison between BNP levels in premature heart contraction according to atrial and ventricular types.

Figure 4 revealed a significant increase (P<0.0001) in atrial premature contraction (703.4± 45.97) in comparison with ventricular (232.1± 17.03).

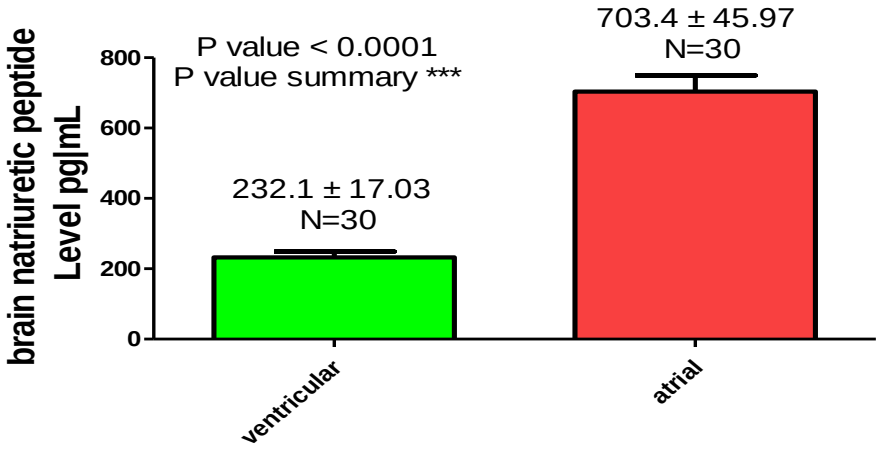

Figure 4: Brain natriuretic peptide Level in ventricular compared with atrial patients.

Comparison between (BNP) levels in premature heart contraction according to new and treated patients.

The results illustrated in Figure 5 show a significant increase (P<0.0001) in new diagnosis patients (719.3 ± 56.74) in comparison with those treated (288.0 ± 25.56).

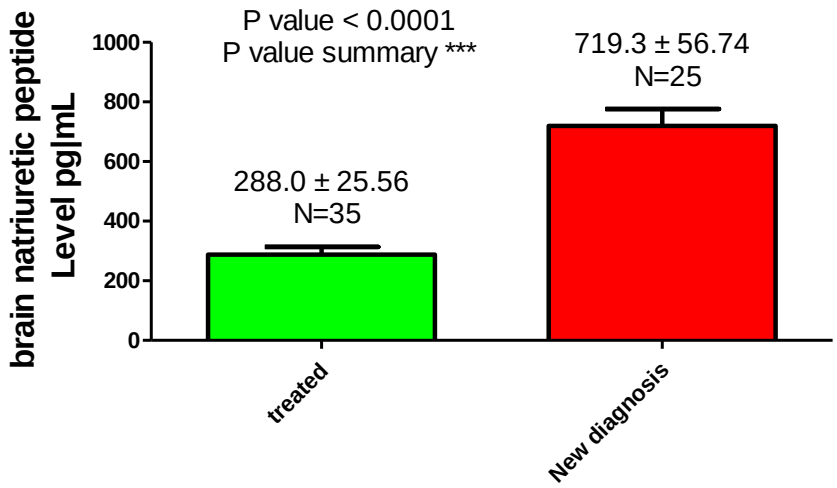

Figure 5: Brain natriuretic peptide Level in new diagnoses compared with treated patients

Comparison between (BNP) levels in premature heart contraction according to hypertension.

In Figure 6, the documentary showed that significant increase (P<0.0001) in hypertensive patients (620.8 ± 43.01) in comparison with normotensive (176.7 ± 11.33).

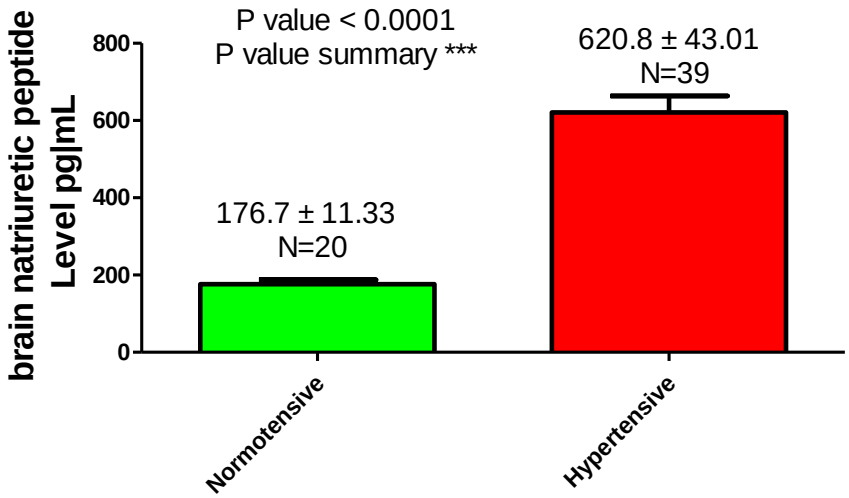

Figure 6: Brain natriuretic peptide Level in normotensive compared with hypertensive patients

Comparison between BNP levels in premature heart contraction according to the duration of the disease.

Figure 7 shows a significant increase (P<0.0001) in duration of disease (1 weak-1 month) (815.8 ± 53.09) in comparison with other durations (1-5) years (378.6 ±19.36) and (>5) years (152.0 ±6.888). The results also indicate a significant increase in duration of disease (1-5) years compared with (>5) years.

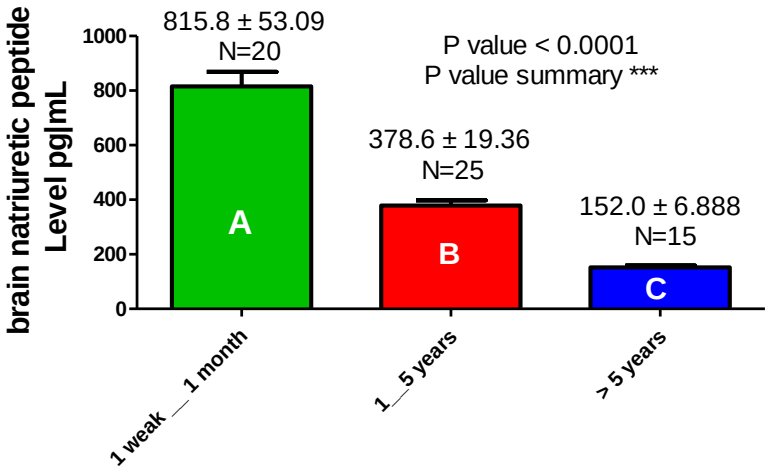

Figure 7: Brain natriuretic peptide Level according to the duration of patients

Comparison between BNP levels in premature heart contraction according to body mass index.

The present results in Figure 8 proved that significant(P<0.0001) difference in obese patients (745.9 ± 49.76) in comparison with overweight (235.8 ± 24.38) and normal weight (282.6 ± 28.35), also overweight patients showed a significant increase (P<0.0001) in comparison with normal weight.

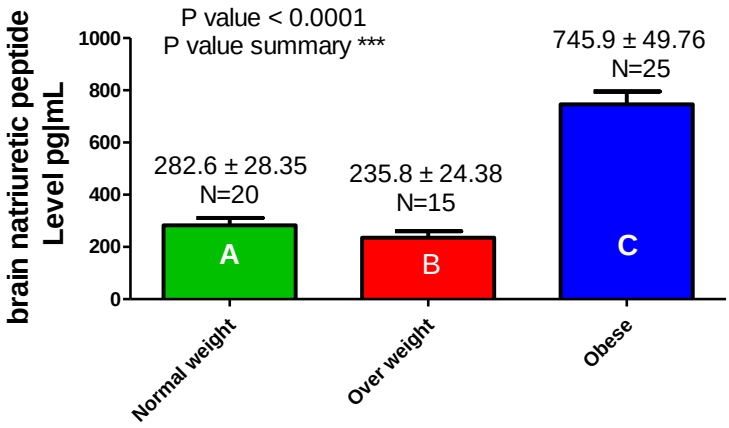

Figure 8: Brain natriuretic peptide Level according to body mass index

Discussion

Figure 1 shows a signification increase (P < 0.05) in patients in comparison with the control groups.

Recent study has been explained the role of (BNP) level in atrial contraction (Atrial fibrillation) and ventricular premature contraction and showed that increased atrial fibrillation and ventricular hypertrophy associated with high level of BNP and consider as biomarkers for early detection of premature heart contraction also lower (BNP) level with no atrial fibrillation (12-14). Another recent study has documented that BNP with higher concentration is a prognostic marker for atrial fibrillation or risk factors before ablation, and lower

BNP was shown after ablation (15,16). The lower BNP level follows up on patients for 3 months with arrhythmia (17,18).

Several researchers on BNP have indicated a prognostic marker secreted by cardiomyocytes in response to wall stress associated with atrial fibrillation and tachycardia (arrythmia), and a low level of Baseline BNP with arrythmia recurrence (19,20). In a previous study, it was shown that atrial fibrillation was 53.3% at high rates related to the high level of BNP (21,22). Recent research by (23) suggested that BNP is a neurohormone secreted by cardiomyocytes and is a predictor of new-onset atrial fibrillation in patients with nonsurgical.

In a former study, it has been explained that BNP is mainly synthesized by the left ventricles and enters circulation through the coronary sinus and is considered a sensitive index for reflecting ventricular load and function; therefore, any stress, tension, pressure overload with changes of the electrocardiogram may be associated with a high level of BNP (24). Many mechanisms have been proven that abnormal depolarization and pathogenesis of ventricular arrhythmia and physiological changes associated with hypertension, with abnormal electrocardiograph (ECG) correlated with high levels of BNP (25).

In a very recent studies have been suggested a very relationship between premature atrial contraction and atrial fibrillation with high concentration of BNP with high atrial diameter (LAD), p-wave terminal force at load also, pv-interval as well as number of premature atrial contraction count especially >10 beats on twenty-four hour found atrial diameter ≥ 38.5 mm, p-wave ≥ 4.0 Mv. sec also prolong P-R. (26). Several studies have suggested that high AF is associated with or predicted based on the number of BNP (27,28).

In a study of (29), it has been proposed that atrial fibrillation is the most prevalent of cardiac arrhythmias and premature atrial contraction that cause morbidity and mortality, and high BNP was associated with atrial stretch, enlargement, volume overload, and fibrosis of the atrium in atrial fibrillation patients.

The mechanism of supraventricular ectopy has been suggested to be correlated with both high levels of NT-pro BNP and Troponin, and is widely increased in atrial fibrillation and supraventricular ectopic activity with existing electrical abnormality, as well as atrial dilation, which leads to atrial myopathy. (30)

The previous study has proved that high BNP with increased left ventricular rate and oxygen mismatch, overload in pressure and volume, blood flow changes, especially in microvascular blood flow, and as a result of these events, high production of BNP was produced (31,32).

In a study of postulated plasmatic, both BNP and NT-pro BNP were used to predict future atrial fibrillation. Also, the concentration of BNP decreases after restoration of sinus rhythm (33).

In recent research, it has been suggested that BNP has a high value for prognostic markers and risk factors for atrial fibrillation, leading to the development of cardiovascular disease and risk of mortality. in addition, atrial flutter also highly occurs with high concentrations of BNP (33,34).

In a study has been explained a restoration of sinus rhythm was corrected with a decrease of both BNP and atrial fibrillation because of a decrease in inflammation, ventricular and atrial endothelial dysfunction. (35)

Recent articles proved an association between the recurrence of atrial fibrillation and BNP because of the high degree of inflammation and dysfunction in sinus rhythm (SR) with high left ventricular ejection fraction (LVEF) (36,37).

In a study dealt with estimation of atrial natriuretic peptide (ANP) with BNP and indicated that ANP was normal, but BNP was high level and explained the

reason for high BNP to secrete small amount of BNP from atria in addition to ventricles and contraction of myocardium in atria produce high effect on myocardium fiber led to activated BNP in atrial fibrillation (38).

In recent report showed that atrial fibrillation, supraventricular arrhythmia, and extrasystole increased the risk of atrial fibrillation and premature atrial contraction, and these events in parallel with myocardial apoptosis and necrosis (39). In a study, of reported that a lower baseline BNP level catheter ablation for atrial fibrillation also associated with improvement of left a ventricular ejection fraction and normal of electrocardiogram.

In very recent research postdated that several factors contribute to stretching wall tension of the heart have a relationship with high BNP level and these factors include AF-rhythm, diastolic dysfunction and heart failure (40). In a previous study it has been proved that BNP is more stable than ANP in secretion and store, in ventricles therefore BNP is considered as a predictive marker for premature atrial contraction and ventricles (41).

A study was suggested the role of BNP level in detection of paroxysmal atrial fibrillation and found higher level in atrial tachycardia (AT) and atrial fibrillation (AF) and used as diagnostic markers and discuss that phenomena as pathophysiological changes lead to hemodynamic load and atrial stretch also abnormal, depolarization of the heart and P-wave, may lead to AT and AF(42).

Figure 2 of the present study indicated a signification increase in male patients than female patients. No previous study deal with level of BNP pin male in comparison with female in premature contraction patients therefore many reasons contraction in female especially at younger age as protective role against disease and these decrease after menopause, while male have a risk factor at younger age represented by testosterone.

Figure (3) of the current results showed that older age (60-69) years significantly higher increase in BNP than other ages. These results agree with some studies that showed a common arrhythmia and AF prevalence 5% over 65 years, and is mostly common in elderly subjects, and BNP level positively affects with age (43). The present data in Figure 4 showed a signification increase in atrial premature in comparison with ventricles. No previous research dealt with a comparison between the atrial and ventricles. The explanation may be discussing atrial fibrillation. Flutter is most common due to atrial stretch, depolarization, and P-wave disturbances accompanied by a higher level of BNP than the ventricles.

Figures (5) and (6) revealed a signification increase in BNP level in new diagnoses of patients than those treated and the duration of disease, 1 weak-1 month than others. Several recent studies have proved that BNP with a high level of BNP in newly diagnosed patients and considered a predictive biomarker for both atrial and ventricular premature contraction, and this peptide new onset atrial fibrillation, ventricular arrhythmia (44). Some studies have suggested that the high level of BNP in atrial fibrillation patients before surgery or any treatment, such as an antiarrhythmic drug, was success to reduction in reducing BNP (45).

The current results in figure 7 showed a higher BNP in hypertensive patients than normotensive in premature heart contraction. Recent studies agree with the present results and suggest that BNP level modification and association with high concentration with aggressive blood pressure in atrial fibrillation, atrial fibrosis, LVEF, systolic blood pressure than others (46).

Figure 8 in the current results showed that the BNP level is higher in obese individuals than in overweight and normal individuals. Very little data correlates the body mass index with atrial and ventricular premature contraction, except a study of

(46) that associates both gender, age, and body mass index with high BNP level. Obesity may be considered a risk factor that may cause high blood pressure, abnormality in heart rhythm, stretch on atrial wall, supraventricular ejection fraction, and increased depolarization of sinus node with disturbances in ECG reading by P-wave.

Conclusion

1-The current results concluded that the severity of disease is associated with males more than females, in both biomarker levels.

2-The patients that new diagnosed with the duration of disease (1 weak-1 month) were highly affected by both biomarkers' levels.

3-Older ages also have high blood pressure, with high body mass index considered a risk factor for premature heart contraction due to high levels of both biomarkers.

Conflict of interest: NIL

Funding: NIL

References

1- Khanna S, Sreedharan R, Trombetta C. Cardiovascular Physiology. In Basic Sciences in Anesthesia 2025 Jan 10 (pp. 319-349). Cham: Springer Nature Switzerland.

2- Al-Najeem HT, Al-Dujaili AN. Assessment of bone morphogenetic protein receptor 2 level in pulmonary arterial hypertension disease. Research Journal of Pharmacy and Technology. 2017;10(8):2614-8.

3- Rubattu S, Gallo G, Volpe M. The Balance Between the Natriuretic Peptides and the Renin-Angiotensin-Aldosterone System in the Preservation of Ideal Cardiovascular Health. Journal of Clinical Medicine. 2025 Jan 19;14(2):626.

4- Al-Fatlawi NA, Al-Dujaili AN, Kammona TH. Assessment B-cell-activating factor (BAFF) in thrombocytopenia patients. InAIP Conference Proceedings 2020 Dec 4 (Vol. 2290, No. 1). AIP Publishing.

5- Vergani M, Cannistraci R, Perseghin G, Ciardullo S. The role of natriuretic peptides in the management of heart failure with a focus on the patient with diabetes. Journal of Clinical Medicine. 2024 Oct 18;13(20):6225.

6- Saleem H, Al-Dujaily AN, Al-Murshidi MH. Effect of Methanolic Leaf Extract of Moringa oleifera on some Biochemical Markers in obesity induced rats. RESEARCH JOURNAL OF PHARMACEUTICAL BIOLOGICAL AND CHEMICAL SCIENCES. 2016 May 1;7(3):2222-32.

7- Sinha AA, Joshi UP, Awais M. PROFILE OF PATIENTS OF HEART FAILURE AND BNP LEVELS. Int J Acad Med Pharm. 2024;6(2):77-82.

8- Al-Dujaili AN, Al-Kraity WR. Assessment of CD-147 Level in women with coronary heart disease after menopause. Research Journal of Pharmacy and Technology. 2018;11(1):317-20.

9- Takei Y, Inoue K, Trajanovska S, Donald JA. B-type natriuretic peptide (BNP), not ANP, is the principal cardiac natriuretic peptide in vertebrates as revealed by comparative studies. General and comparative endocrinology. 2011 May 1;171(3):258-66.

10- Al-Najeem HT, Al-Dujaili AN. Assessment of Gremlin-1 Level in Pulmonary Arterial Hypertension Disease. Research Journal of Pharmacy and Technology. 2017;10(11):3803-6.

11- Al-Fatlawi NA, Al-Dujaili AN, Kammona TH. Assessment FC gamma receptors (FCGR) IIb in thrombocytopenia patients in Holy-Najaf. In AIP Conference Proceedings 2020 Dec 4 (Vol. 2290, No. 1). AIP Publishing.

12- Writing Committee, Spooner MT, Messé SR, Chaturvedi S, Do MM, Gluckman TJ, Han JK, Russo AM, Saxonhouse SJ, Wiggins NB. 2024 ACC Expert Consensus Decision Pathway on Practical Approaches for Arrhythmia Monitoring After Stroke: A Report of the

American College of Cardiology Solution Set Oversight Committee. Journal of the American College of Cardiology. 2025 Feb 18;85(6):657-81.

13- Shakir Alkhafaji R, Muhsin Khalfa H, Lf Almsaid H. Rat hepatocellular primary cells: A cellular and genetic assessment of the chitosan nanoparticles-induced damage and cytotoxicity. Archives of Razi Institute. 2022 Apr 30;77(2):579-84.

14- khalfa HM, al-msaid HL, abood AH, naji MA, Hussein SK. Cellular genetic expression of purinergic receptors in different organs of male rats injected with cyclophosphoamide. InAIP Conference Proceedings 2020 Dec 4 (Vol. 2290, No. 1, p. 020033). AIP Publishing LLC.

15- Rienstra M, Van Gelder IC, Van den Berg MP, Boomsma F, Van Veldhuisen DJ. Natriuretic peptides in patients with atrial fibrillation and advanced chronic heart failure: determinants and prognostic value of (NT-) ANP and (NT-pro) BNP. Europace. 2006 Jul 1;8(7):482-7.

16- AL-Msaid HL, Waleed AH, AL-Sallami AS. Relationship Between Hyperviscosity and Sex Hormone in Azoospermia and Oligozoospermia Patients Compares with The Control Group. Int J Pharm Qual Assur. 2019;10(4):637-9.

17- Hamatani S, Matsumoto K, Takahashi J, Shiko Y, Ozawa Y, Niitsu T, Hirano Y, Shimizu E. Feasibility of guided internet-based cognitive behavioral therapy for patients with anorexia nervosa. Internet Interventions. 2022 Mar 1;27:100504.

18- AL-Msaid HL, Khalfa HM, Rashid AA, Hussain NN. Relationship between Sperm DNA Fragmentation and Interleukin 17 in Patients with Leukocytospermia. Journal of Bioscience and Applied Research. 2024 Nov 21;10(4):809-15.

19- Keefe JA, Garber R, McCauley MD, Wehrens XH. Tachycardia and atrial fibrillation-related cardiomyopathies: potential mechanisms and current therapies. Heart Failure. 2024 Apr 1;12(4):605-15.

20- AL-Msaid HL, Aledhari M, Alrehbawy R. Investigation of Some Clinical Parameters in Renal Failure Patients. Journal of Bioscience and Applied Research. 2024 Dec 19;10(6):174-9.

21- Shi Y, Deng D, Song N. Up-to-date advance in the relationship between obstructive sleep apnea and heart failure: a narrative review. Sleep and Breathing. 2025 Mar;29(1):2.

22- Faraj, H. Serum NT-pro BNP and Other Biochemical Markers in Patients with Cardiorenal Syndrome (CRS) in Thi-Qar province- Iraq. *Journal of Bioscience and Applied Research*, 2024; 10(4): 686-694. doi: 10.21608/jbaar.2024.311161.1064

23- Chaikijurajai T, Demirjian S, Tang WW. Prognostic value of natriuretic peptide levels for adverse renal outcomes in patients with moderate to severe acute kidney injury with or without heart failure. Journal of the American Heart Association. 2023 Nov 7;12(21):e031453.

24- De La Espriella R, Cobo M, Santas E, Verbrugge FH, Fudim M, Girerd N, Miñana G, Górriz JL, Bayés-Genís A, Núñez J. Assessment of filling pressures and fluid overload in heart failure: an updated perspective. Revista Española de Cardiología (English Edition). 2023 Jan 1;76(1):47-57.

25- Xu X, Zheng H. Correlation analysis of cardiac electrophysiological characteristics and cardiovascular disease progression in arrhythmia patients. American Journal of Translational Research. 2025 Jan 15;17(1):178.

26- Chin JF, Aga YS, Abou Kamar S, Snelder SM, Kardys I, de Boer RA, Brugts JJ, van Dalen BM. Exploring risk Indicators of atrial fibrillation in severe Obesity: Left atrial cardiomyopathy and premature atrial contractions. IJC Heart & Vasculature. 2024 Dec 1;55:101555.

27- Ammar LA, Massoud GP, Chidiac C, Booz GW, Altara R, Zouein FA. BNP and NT-proBNP as

prognostic biomarkers for the prediction of adverse outcomes in HFpEF patients: A systematic review and meta-analysis. Heart Failure Reviews. 2025 Jan;30(1):45-54.

28- Wang W, Zhou T, Li J, Yuan C, Li C, Chen S, Shen C, Gu D, Lu X, Liu F. Association between NT-proBNP levels and risk of atrial fibrillation: a systematic review and meta-analysis of cohort studies. Heart. 2025 Feb 1;111(3):109-16.

29- Chin JF, Aga YS, Abou Kamar S, Snelder SM, Kardys I, de Boer RA, Brugts JJ, van Dalen BM. Exploring risk Indicators of atrial fibrillation in severe Obesity: Left atrial cardiomyopathy and premature atrial contractions. IJC Heart & Vasculature. 2024 Dec 1;55:101555.

30- Shoureshi P, Tan AY, Koneru J, Ellenbogen KA, Kaszala K, Huizar JF. Arrhythmia-induced cardiomyopathy: JACC state-of-the-art review. Journal of the American College of Cardiology. 2024 Jun 4;83(22):2214-32.

31- Mouzarou A, Hadjigeorgiou N, Melanarkiti D, Plakomyti TE. The Role of NT-proBNP Levels in the Diagnosis of Hypertensive Heart Disease. Diagnostics. 2025 Jan 6;15(1):113.

32- Tikki KA, Al-Ethari AS, Al-Msaid HL. The effect of fingolimod drug on blood profile in multiple sclerosis patients. InAIP Conference Proceedings 2023 Dec 22 (Vol. 2977, No. 1). AIP Publishing.

33- Karakasis P, Theofilis P, Vlachakis PK, Korantzopoulos P, Patoulias D, Antoniadis AP, Fragakis N. Atrial fibrosis in atrial fibrillation: mechanistic insights, diagnostic challenges, and emerging therapeutic targets. International Journal of Molecular Sciences. 2024 Dec 30;26(1):209.

34- Ammar LA, Massoud GP, Chidiac C, Booz GW, Altara R, Zouein FA. BNP and NT-proBNP as prognostic biomarkers for the prediction of adverse outcomes in HFpEF patients: A systematic review and meta-analysis. Heart Failure Reviews. 2025 Jan;30(1):45-54.

35- Ali LO, Khalfa HM, Al Sahlanee R, Almsaid HL. Histological changes in liver and cardiac rat tissues after exposure to chitosan nanoparticles orally. Medical Journal of Babylon. 2023 Jan 1;20(1):215-8.

36- Dosh RH, Khalfa HM, Al-Rehemi SM, Almsaid HL, Hadi N. IN VIVO ACTIVATION OF P2Y4 PURINERGIC RECEPTORS USING ATP IN RAT EPIDERMAL TISSUE. Wiadomości Lekarskie monthly journal. 2022;75(11):2729-33.

37- Kittipibul V, Lam CS. Heart failure with preserved ejection fraction and atrial fibrillation: epidemiology, pathophysiology, and diagnosis interplay. Heart Failure Reviews. 2025 Jan 24:1-9.

38- Al-nuani RM, Kadhim NJ. The effect of Capparis Spinosa L. Plant on the cytochrome and glutathione to reduce the hepatotoxicity induced by paracetamol in mice. InJournal of Physics: Conference Series 2020 Nov 1 (Vol. 1664, No. 1, p. 012121). IOP Publishing.

39- Al-Hadraawy SK, AL-Shebly FM, Abood AH, Kadhim NJ. Correlation study between biological markers in patients with Entamoeba histolytica parasite. Biochem. Cell Arch. 2019 Apr 1;19(1):126.

40- Al-Hadraawy SK, AL-Shebly FM, Abood AH, Kadhim NJ. Correlation study between biological markers in patients with Entamoeba histolytica parasite. Biochem. Cell Arch. 2019 Apr 1;19(1):126.

41- Schotten U, Verheule S, Kirchhof P, Goette A. Pathophysiological mechanisms of atrial fibrillation: a translational appraisal. Physiological reviews. 2011 Jan;91(1):265-325.

42- Antoun I, Layton GR, Nizam A, Barker J, Abdelrazik A, Eldesouky M, Koya A, Lau EY, Zakkar M, Somani R, Ng GA. Hypertension and Atrial Fibrillation: Bridging the Gap Between Mechanisms, Risk, and Therapy. Medicina. 2025 Feb 19;61(2):362.

43- El-Shorbagy EA, Elsayed AA, Abuelsoud NN. The role of brain natriuretic peptide biomarker in the detection of cardiotoxicity. ERU Research Journal. 2025 Jan 1;4(1):2038-62.

44- Liu Z, Liu T, Wu G. Atrial Cardiomyopathy: From Diagnosis to Treatment. Reviews in Cardiovascular Medicine. 2025 Jan 20;26(1):25124.

45- Yagasaki H, Suzuki T, Watanabe K, Warita S, Iwama M, Noda T. Severe cibenzoline toxicity in hypertrophic obstructive cardiomyopathy successfully managed with extracorporeal membrane oxygenation and percutaneous transluminal septal myocardial ablation—A case report. Journal of Cardiology Cases. 2025 Feb 26.

46- Mouzarou A, Hadjigeorgiou N, Melanarkiti D, Plakomyti TE. The Role of NT-proBNP Levels in the Diagnosis of Hypertensive Heart Disease. Diagnostics. 2025 Jan 6;15(1):113.