AMJ
ISSN: 0005-2523

ISSN: 0005-2523
Volume 62, Issue 10, December, 2022

BETA-HYDROXYBUTYRATE DEHYDROGENASE IN MYOCARDIAL INFARCTION AND ANGINA PECTORIS PATIENTS

Eman A W Al-Hyali[1], Mahmoud AM Fakhri[2*]

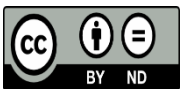
Department of Chemistry, College of Science, University of Mosul, Iraq[1]
Department of Medical Physics, College of Science, University of Mosul, Iraq[2]

Corresponding author: 2*

Keywords:
Beta-hydroxybutyrate dehydrogenase, Heart Disease, BHBDH, Myocardial Infarction, Angina Pectoris, Creatine kinase–MB.

ABSTRACT

The research included a study of the activity of serum β-hydroxybutyrate dehydrogenase (BHBDH) and some biochemical parameters for 147 heart patients (68 myocardial infarction and 79 angina pectoris). The results showed that the group of heart patients who received serum-hydroxybutyrate dehydrogenase increased their activity significantly (224.12 ± 0.82 U/L) compared to the control group (136.73 ± 0.95 U/L). The activity for serum β-hydroxybutyrate dehydrogenase activity for the heart patients group was affected by age and sex, while it was not affected by body mass index and smoking. It also showed a significant increase in levels of haemoglobin, PCV, Glucose, Urea, GPT, GOT, TC, TG, LDL-C, VLDL-C, MPO, LDH, CK-MB with the control group and heart patients group, while showed a significant decrease in levels for ARE, HDL-C. The results showed no significant difference was observed between serum β-hydroxybutyrate dehydrogenase activity in the myocardial infarction group (225.114±1.26 U/L) and angina pectoris group (223.112±1.08U/L), while there was a significant difference in Hb, PCV, Glu, Alb, GOT, GPT, LDH, CK-MB between myocardial infarction patients group and angina pectoris patients group. A linear significant relationship was also found between serum β-hydroxybutyrate dehydrogenase activity with Hb and PCV, while was a linear significant inverse relationship between serum β-hydroxybutyrate dehydrogenase activity with LDL-C, T.C and T.G in the group of heart patients.

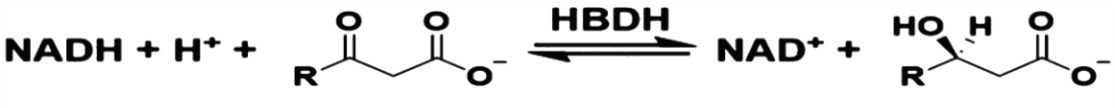


1. Introduction

Heart disease (HD) is a major health problem that affects a large number of people all over the world. breathing difficulty, Muscle weakness and swollen feet are common symptoms of HD. Researchers are working to develop a reliable method for the diagnosis of heart problems [1]. and Heart disease is one of the leading causes of death globally [2]. The most common heart diseases are myocardial infarction and angina pectoris.

Known also as myocardial infarctions, heart attacks, happen when a portion of the heart muscle does not receive adequate blood flow and are major causes of heart disease For myocardial infarctions survivors to survive, early intervention is essential [3]. Chest pain of cardiac origin is called angina pectoris (which comes from the Latin word "angere," which means to choke) [4]. Angina is characterized as an uneasy sensation rather than pain, and it usually involves discomfort and pain. Negative feelings that patients describe include heartburn, constriction, a gang-like sensation, heaviness, an elephant sitting on its chest, tightness, toothache, and burning [5]. Other terms that patients frequently use are squeezing, squeezing, pulling, burning, and knots in the centre of the chest, such as a bra that's too tight and squeezing in the throat [6].

The enzyme B-hydroxybutyrate Dehydrogenase (EC 1.1.1.30) is found in abundance. of single-celled organisms and belongs to the class of redox enzymes Dehydrogenase, the enzyme catalyzes reverse redox reaction between 3-hydroxybutyrate and acetoacetate (ACAC) using NAD+ or NADH [7].



R=CH3: Acetoacetate and (R)-3-hydroxybutyrate, R=CH_2CH_3:3-Oxovalerate and (R)-3-hydroxyvalerate [8]

Acetoacetate is converted to beta-hydroxybutyrate in the liver by beta-hydroxybutyrate dehydrogenase, which is a reductive energy ready for export to organs beyond the liver, such as the brain and heart [9]. According to studies, beta-hydroxybutyrate dehydrogenase is essential for the management and prevention of neurological disorders [10]. Increased myocardial use of β-hydroxybutyrate leads to a decrease in heart failure HF, so increasing β-hydroxybutyrate is considered a way to treat patients with heart failure [11]. Ketone bodies, including acetoacetate, Small molecules such as acetone and beta-hydroxybutyrate are mostly produced in the mitochondria of the liver and transferred beyond the liver. When there is too much fat, tissues like the heart, brain, and muscles oxidize. Acids and carbohydrates are scarce resources. The two primary ketone bodies that the heart uses are acetoacetic acid and BHB [12].

Lactate dehydrogenase is an enzyme found in many organs and tissues throughout the body, including the heart, pancreas, kidneys and blood cells, but it is mostly found in the liver [13].

It is an intracellular enzyme involved in anaerobic glycolysis and catalyzes the conversion of pyruvate to lactate. LDH enzyme serum is being clinically tested for many diseases. High levels of LDH in the blood have been linked to a variety of diseases., including tumours and infections [14]. The current study put out the hypothesis that LDH, which has prognostic value in ADHF, indicates myocardial injury, systemic lung damage, and hepatic congestion [15].

CK-MB is a biomarker of cardiac damage and serves as a potential adjunct test in clinical medicine [16]. Creatine kinase- MB (CK-MB), Myocardial vital signs are routinely utilized to determine whether a myocardial infarction has occurred. Within 4 to 8 hours of the onset of chest discomfort, Blood can reveal CK-MB concentrations; It increases when the heart muscle cells are injured and returns to normal after (48) hours [17].

Arylesterase is one of the hydrolytic enzymes (EC3.1.1.2). It is associated with HDL and is a member of the

ISSN: 0005-2523
Volume 62, Issue 10, December, 2022

esterase family. The enzyme is what gives HDL its antioxidant properties. As it goes to the area of the lesion to stop LDL lipid peroxidation, the enzyme helps to prevent the oxidation of the lipids in lipoproteins and atherosclerotic lesions. It breaks down the oxidized fats there. Patients with myocardial infarction and angina pectoris showed decreased Are activity, which is a sign of elevated oxidative stress [18], [19].

Myeloperoxidase is an enzyme have a prosthetic group of redox enzymes that contain heme and are members of the peroxide family [20]. It is a crucial element in the efficient oxidation of white blood cells, which gives them the ability to fight against various parasites and bacteria [21]. high levels of MPO are associated with heart disease, neurological system disorders, and vascular diseases [22]. Demonstrating that MPO is important in the development of atherosclerosis and unstable plaques [23]. An inflammatory marker called myeloperoxidase (MPO) is elevated in acute myocardial infarction (AMI), one of the most severe acute coronary syndromes [24].

This research aims to find the level of the activity of Beta-hydroxybutyrate Dehydrogenase in patients with myocardial infarctions and angina pectoris, and with Comparing it with healthy people. addition to studying the connection between a particular enzyme and other biological factors.

2. Materials and procedures

Study subjects: The study was conducted at Al-Salam Hospital and Cardiac Center in Mosul, 147 blood samples were collected from patients with heart diseases, which included (68) myocardial infarctions (40 males and 28 females), and (79) angina pectoris (46 males and 33 females). Al-Salam and the Mosul Center for Cardiac Medicine and Surgery, their ages ranged between (80-30) years, (94) blood samples were collected from apparently healthy people, including (34) males and (60) females, their ages ranged between (67-30) years. Then, the serum was separated from the coagulated part of the blood using a centrifuge for 20 minutes at a speed of 4000xg.

3. Measurement of parameters

In order to assess -hydroxybutyrate dehydrogenase, nicotinamide adenine dinucleotide solution (30 mM) and sodium salt of -hydroxybutyrate (160 mM) (the substrate) were utilized. The reaction mixture was maintained at pH 7.8, 100 mM Tris-HCl buffer, and 37 °C

Glucose, creatinine, urea, albumin, total protein, Globulin, alanine aminotransferase (GPT), aspartate aminotransferase (GOT), total cholesterol (TC), triglyceride (TG), and high-density lipoprotein (HDL-C), The specification, used kit suppliers, and measurements made in accordance Follow the directions provided by the manufacturer in Table 1 below.

Low-density lipoprotein cholesterol estimation using the Friedewald equation [26] LDL cholesterol equals TC - (TG/5) - HDL cholesterol. The Fischbach equation was used to compute the cholesterol from very low-density lipoprotein by substituting VLDL concentration (mg/dl) for triglyceride (5), Equation: Globulin = Total protein - Albumin was used to calculate the amount of globulin [27], [28].

Table1. Kits are used for measuring the studied parameters

Kit Information	Catalogue Number	Suppliers
Glucose liquicolor	1 0 2 6 0	Human (Germany)
Urea liquicolor	1 0 5 0 5	
Creatinine liquicolor	1 0 0 5 1	

Total Protein Biuret Method	8 0 0 1 6	Biolabo (France)
Albumin BCG Method	8 0 0 0 2	
GPT (IFCC)	8 0 0 2 7	
GOT (IFCC)	8 0 0 2 5	
TRIGLYCERIDES GPO	8 0 0 1 9	
HDL CHOLESTEROL (PTA)	8 6 5 1 6	
CHOLESTEROL CHOD PAP	8 0 1 0 6	

Lactate dehydrogenase, Based on the modified spectroscopic approach, the activity of the lactate dehydrogenase enzyme was determined using a pre-made kit from the French company Biolabo [29]. Creatine kinase–MB activity was estimated by using a Cobas device from Roche company (Germany), using the ultraviolet immunofluorescence method, which tracks the course of the reaction at 340nm wavelength [30]. Aryl esterase [31] Arylesterase testing was done. The substrate in a Tris-HCl buffer (9 mM pH 8) with calcium chloride in distilled water is phenylacetate (5 mM). Based on this, myeloperoxidase was estimated. [32]. utilizing a citrate buffer with a pH of 5.5, a substrate of O-dianisidin at a concentration of 20.568 mM, and a hydrogen peroxide solution of 1.5% in a dimethyl sulfoxide solution.

4. Statistical Analysis

SPSS 22.0 was used to examine numerical data. The means and standard errors for all data were displayed. The correlation coefficient (r) was used to found the relationship between activity of serum β-hydroxybutyrate dehydrogenase with other biochemical parameters in heart patient group.

5. Results and Discussion

The activity of BHBDH was estimated in the serum of apparently healthy subjects, their ages ranged (65-30 years), males and females. The normal range of BHBDH enzyme activity was found in the serum of the control group (136.73 ± 0.954 U/L) and in a group of heart patients' blood serum, whose ages ranged between (75-33 years) of both sexes, The enzyme activity of beta-hydroxybutyrate dehydrogenase was determined. The rate of enzyme activity in the serum of the heart patients group was discovered to be (224.11±0.823U/L) As shown in Table 2.

BHBDH activity was compared between all heart patients group and the control group for both age groups, gender, the effect of smoking, and body mass index. Table 2 displays the impact of age by age categories in the control group and the patient group. with myocardial infarction and angina pectoris for all stroke and angina patients compared control group. A very significant difference was observed at $p \leq 0.001$, and a significant difference between the first age group the second age group and the third age group. The heart patients group had a very high significant difference at $p \leq 0.001$, in addition to the presence of a difference between the two groups, i.e. males with females in both groups as the world showed them [33].

There is also a significant increase at $p \leq 0.001$ for the effects of smoking (both smokers and non-smokers) on the heart patients group and control group, there is also a significant difference at $p \leq 0.001$ for the effects of smoking (smokers and non-smokers) on heart patients group and control group, as explained by [34]. Smoking causes arterial wall breakdown, increased blood clot formation, increased oxidative stress and active oxygen species as in table 2.

In addition to the body mass index, which shows in table 2، According to BMI, they were divided into four groups. of the control group, and compared with the control group, the enzyme activity increases in patients

ISSN: 0005-2523
Volume 62, Issue 10, December, 2022

with myocardial infarction and angina pectoris. There is a significant increase at p≤0.001 between BMI for the heart patients group and the control group, and a difference was observed between BMI for the first group with the other groups as interpreted by the scientist [35]. the reason is due to the accumulation of fat in the fatty tissues.

5.1 Clinical parameters in heart patients group and control group

It is noted in Table 3, which represents the relationship for parameters with heart patients group and control group. Where there was a very high significant difference in Hb, PCV, Glucose, Urea, GPT, TG, TC, LDL - C, V LDL-C, HDL-C, MPO, Are, LDH, CK-MB As for the rest of the parameters, there is no significant difference such as Creatinine, Globulin.

Table 2. The activity of BHBDH enzyme in the serum of patients with heart patients group and control group

Influencing factors	Groups	The activity of BHBDH (U/L)		P - values
		Controligroup Mean±S.E	Heart Patientsigroup Mean±S.E	
Age group	44≥	125.57 ± 0.64 A	213.56± 1.15 A	P≤ 0.001
	45-55	135.99± 0.63 B	221.64±0.71 B	P≤ 0.001
	56≤	146.61 ± 0.62 C	229.89 ± 0.89 C	≤ 0.001
Sex	Male	142.84 ± 1.43 A	226.73 ± 0.97 A	P≤ 0.001
	Female	133.26 ± 1.02 B	219.17 ±1.09 B	P≤ 0.001
Effect of Smoking	Smoking	149.68 ± 0.86 A	225.61 ±1.25 A	P≤ 0.001
	Non-smoking	135.52± 0.94 B	222.89 ± 1.35 A	P≤ 0.001
Body Mass Index	18.5-24.9	130.64 ±1.68 A	223.18 ±2.22 A	P≤ 0.001
	25-29.9	138.70±1.74 B	223.68 ±1.13 A	P≤ 0.001
	30-34.9	139.20±1.33 B	224.15 ± 1.84 A	P≤ 0.001
	35-39.9	141.43 ± 2.38 B	225.84 ±1.92 A	P≤ 0.001
Type of heart disease	Angina pectoris	136.73 ±0.95	223.112±1.08 A	P≤ 0.001
	Myocardial infarction		225.114±1.26 A	P≤ 0.001
Total		136.73 ±0.95	224.112±0.82	P≤ 0.001

There is a moral difference in the Hb parameter with the heart patients group for the control group, as the world reported [36] Elevated haemoglobin concentrations severely reduce blood flow throughout the body

as red blood cells are the main factors that determine blood viscosity. The table3 also shows the very high importance of Glucose in heart diseases. This is because the high level of sugar leads to its accumulation in the blood cells and thus works to block the blood vessels that carry blood to and from the heart, causing damage and thus preventing the delivery of oxygen and nutrients to the heart [37].

The significant difference in Table 3 for urea between the heart patients group and control group is due to The heart's capacity to pump blood may decline. This decrease in blood flow may lessen the amount of blood that the kidneys are able to filter, raising the level of urea in the body، As interpreted by scholars [38].

Table 3 indicates that there is a significant increase at p≤0.001 in the activity of GPT enzyme in the heart patients group compared to the control group, and this is consistent with what I found [39], [40] as this enzyme is secreted from the liver and muscle cells. Heart muscle or hepatocytes, cause the enzyme to be released into the blood.

As lipid disorders are the main risk factor for heart disease, the results also demonstrated in the previous table3 a significant difference in the concentration of TG, TC, LDL-C, VLDL-C, and HDL-C in the heart patients group compared to the control group. The cause of this may be attributed to the nature of nutrition, which is represented by a high percentage of saturated fats that result in high cholesterol levels [41].

Table3. Clinical parameters of heart patients group compared to control group

Clinical Parameters	Control-group Mean±S.E	Heart Patientsigroup Mean±S.E	P - values
Hb b (g/dl)	12.99 ±0.18	14.06 ± 0.18	P ≤ 0.01
PCV %	38.97 ±0.54	42.1745 ± 0.54	P ≤ 0.01
Glucose (mg/dl)	93.102 ± 1.28	174.09 ± 10.79	p ≤ 0.001
Urea (mg/dl)	25.90 ± 0 .42	30.68 ± 1.29	P ≤ 0.001
Creatinine (mg/dl)	0.831 ± 0.03	0.894 ± 0.07	P > 0.05
T.P (g/dl)	7.111 ± 0 .05	6.931 ±0.08	p > 0.05
Alb. (g/dl)	3.830 ± 0 .05	3.665 ± 0.05	p ≤ 0.05
Globulin (g/dl)	3.281 ± 0.04	3.265 ± 0.07	p > 0.05
GOT (U/L)	32.553 ± 1.29	42.714 ± 4.03	p ≤ 0.05
GPT (U/L)	12.313 ± 1.08	19.0408 ±1.40	p ≤ 0.001
T .C (mg/dl)	170.00 ± 3.30	244.25 ± 4.35	p ≤ 0.001
T.G (mg/dl)	136.26 ± 4.50	225.35 ± 4.35	p ≤ 0.001
HDL-C (mg/dl)	47.0000 ± 0.69	33.91 ± 1.05	p ≤ 0.001
LDL-C (mg/dl)	95.749 ± 3.43	165.27± 4.02	p ≤ 0.001
VLDL-C (mg/dl)	27.251 ± 0.90	45.07 ± 0. 87	p ≤ 0.001
MPO (U/L)	27.359 ± 0.64	42.7604±2.44	p ≤ 0.001
ARE (U/L)	101.463 ±1.37	79.5324±1.86	p ≤ 0.001
LDH (U/L)	169.39 ± 3.91	324.22±11.06	p ≤ 0.001
CK-MB (U/L)	8.545 ± 0.41	33.294 ± 4.69	p ≤ 0.001

A very significant difference P ≤ 0.001, ** Great moral difference p≤ 0.01, *moral difference p≤ 0.05

ISSN: 0005-2523
Volume 62, Issue 10, December, 2022

The results presented in When comparing the cardiac patients group to the control group, Table 3 shows an increase in MPO enzyme activity at P0.001, which is similar with what was discovered by [42]. The reason for this is due to an increase in the secretion of the enzyme MPO from neutrophils and monocytes in response to the accumulation of LDL-C in the lining of the artery to participate in the oxidative process.

The results in Table 3 indicated that there was a significant decrease in the concentration of ARE enzyme at ≤ 0.001 p in the heart patients group compared to the control group. The rationale is that by preventing blood lipoproteins from being oxidized, this enzyme plays a significant role in protecting coronary arteries. This is due to the fact that esterase, an antioxidant enzyme, attaches to HDL-C to stop LDL-C oxidation [43]. The activity of CK-MB & LDH was significantly higher in the heart patients group compared to the control group, and this is consistent with what was discovered by [44]. This leads to the release of blood enzymes.

5.2 Clinical parameters of myocardial infarction& angina pectoris groups compared to the control group

The results in Table 4 showed a significant increase at p ≤ 0.001 in the group of myocardial infarction group compared to the control group in (Glucose, Creatinine, Urea, Alb, GOT, GPT, TC, TG, HDL-C, LDL-C, VLDL-C, MPO, Are, LDH, CK-MB), and it found a significant difference between angina pectoris group and control group in Table 4 in each of (Glucose, Urea, Hb, PCV, Alb, GPT, TC, TG, HDL-C, LDL-C, VLDL-C, MPO, Are, LDH, CK- MB). The myocardial infarction group and the angina pectoris group were found to have significant differences in each of the criteria. (Hb, PCV, Glucose, Alb, GOT, GPT, LDH, CK-MB).

The results shown in Table 4 showed that there was no significant difference between the creatinine, TP and globulin parameters for both groups of angina and Myocardial infarction with the control group, While there is a difference between the other parameters as shown in Table 4.

The findings in Table 4 revealed a considerable prevalence of p≤ 0.001 in Hb & PCV in the angina pectoris group compared to the control group, while there was no significant difference in the myocardial infarction group compared to the control group. A significant difference was observed in the activity of LDH, CK-MB enzyme in MI and angina pectoris groups against the control group. The reason is due to its increase in the blood due to the presence of necrosis in the heart muscles and the death of cardiac cells [45].

In Table 4, a significant difference was observed in the activity of ALT & AST enzymes in groups of patients with angina pectoris and MI groups compared to the control group. The reason is due to heart tissue injury, necrosis, or damage to the heart muscle due to the flow of large amounts of ALT &AST enzymes into the bloodstream, as interpreted by the researcher [46].

The relationship of the measured biochemical parameters shown in Table 5 with the activity of BHBDH enzyme for a group of heart patients was studied by finding the linear correlation coefficient "r", and it was found that there is a significant direct relationship at p≤ 0.05 between Hb, PCV and BHBDH enzyme in heart patients group to increase production of red blood cells naturally to compensate for the lack of oxygen supply [47]. The results in Table 5 showed an inverse significant relationship at P≤ 0.05 in the activity of the BHBDH enzyme and the concentration of TG, TC & VLDL-C in the heart patients group.

Table 4. Clinical parameters Measured in angina pectoris, myocardial infarction groups and control group

Clinical	Control group	Myocardial infarction	Angina pectoris

parameters	Mean±SE	group Mean±SE	group Mean±SE
Hb (g/dl)	12.99 ±0.18 A	13.511 ± 0.31 A	14.36±0.21 B***
PCV(%)	38.97 ±0.54 A	40.534 ± 0.94 A	43.09 ±0.63 B***
Glucose (mg/dl)	93.10 ± 1.28 A	214.39±23.17 B***	151.69±9.86 C***
Urea (mg/dl)	25.90 ± 0 .42 A	30.00 ± 1.96 B	31.057±1.69 B**
Creatinine (mg/dl)	0.83 ± 0.0 3 A	1.027±0.17 A	0.820±0.0 5 A
TP (g/dl)	7.11 ± 0 .15 A	6.931 ±0.15 A	6.932±0.19 A
Alb. (g/dl)	3.83 ± 0 .05 A	3.491 ± 0.11 B***	3.762±0.12 A
Globulin (g/dl)	3.29 ± 0.14 A	3.437 ± 0.12 A	3.169±0.17 A
GOT (IU/L)	32.55 ± 1.30 A	58.31±2.62 B*	34.048±2.13 A
GPT (IU/L)	14.31 ± 1.08 A	23.114 ±3.27 B**	16.778±1.13 A*
TC (mg/dl)	170.00 ± 3.29 A	244.27±7.49 B***	244.24±5.37 B***
TG (mg/dl)	136.26 ± 4.50 A	225.37±7.49 B***	225.34±5.37 B***
HDL- C (mg/dl)	47.00 ± 0.69 A	34.062±1.93 B***	33.825±1.25 B***
LDL-C (mg/dl)	95.75± 3.43 A	165.13±6.98 B***	165.34±4.94 B***
VLDL-C (mg/dl)	27.25± 0.90 A	45.074± 1.50 B***	45.067±1.07 B***
MPO (U/L)	27.36 ± 0.64 A	44.231 ±4.21 B***	41.944±3.00 B***
ARE (U/L)	101.46 ±1.37 A	83.694±1.46 B***	77.221±2.74 B***
LDH (U/L)	169.39 ± 3.91 A	368.57±27.78 B***	299.58±5.95 C***
CK-MB (U/L)	8.545 ± 0.41 A	58.246± 4.69 B***	19.431±0.78 C***
***very significant difference P≤ 0.001 ,** Great moral difference p≤ 0.01,*moral difference p≤ 0.05			

Table 5. Relationship between serum activity of beta-hydroxyButyrate Dehydrogenase with clinical parameters in heart patient group

Clinical parameters	Pearson Correlation	P - values
Hb (g/dl)	0.225*	P≤ 0.05
PCV (%)	0.225*	P≤ 0.05
TC (mg/dl)	-0.200*	P≤ 0.05
TG (mg/dl)	-0.200 *	P≤ 0.05
VLDL-C (mg/dl)	-0.200*	P≤ 0.05
moral difference p≤ 0.05		*

6. Conclusion

Determination According to the research, serum beta-hydroxybutyrate dehydrogenase activity was increased in There was no difference between the heart patients' group and the control group. in enzyme activity between patients with myocardial infarction and those with angina pectoris. Therefore, in addition to the enzymes LDH and CK-MB, this enzyme can be used as a marker of heart disease. In addition, there was a relationship between the BHBDH enzyme and the Hb, PCV, T.C, T.G, and VLDL-C parameters in the heart patients group.

Acknowledgements

We would like to express our gratitude to the Al-Salam Hospital administration. and the Center for Cardiac Diseases in Mosul, to the doctors and laboratory staff for their cooperation with us in completing this research, and many thanks to the management of laboratories of Faculty of Science, Department of Chemistry and Medical Physics, without them, this research would not have been completed.

ISSN: 0005-2523
Volume 62, Issue 10, December, 2022

7. References

[1] Li, J. P., Haq, A. U., Din, S. U., Khan, J., Khan, A. & Saboor, A. (2020). Heart disease method using machine learning classification in e-healthcare. IEEE Access, 8, 107562-107582.

[2] Ahmed, H., Younis , E. M., Hendawi, A. & Ali, A. A. (2020). Heart disease identification from patients' social posts, machine learning solution on Spark. Future Generation Computer Systems, 111, 714-722.

[3] Fang, J., Luncheon, C., Ayala, C., Odom, E. & Loustalot, F. (2019). Awareness of heart attack symptoms and response among adults—United States, 2008, 2014, and 2017. Morbidity and Mortality Weekly Report, 68(5), 101.

[4] Ford, T. J. & Berry, C. (2020). Angina: contemporary diagnosis and management Heart, 106(5), 387-398

[5] Shao, C., Wang, J. Tian, J. & Tang, Y. D. (2020). Coronary artery disease: from mechanism to clinical practice. Coronary Artery Disease: Therapeutics and Drug Discovery, 1-36.

[6] Mahler, S. A. (2020). Angina pectoris: Chest pain caused by fixed epicardial coronary artery obstruction. UpToDate [internet].

[7] Hoque MM, Shimizu S, Juan EC, Sato Y, Hossain MT, Yamamoto T, Imamura S, Suzuki K, Amano H, Sekiguchi T, Tsunoda M, Takénaka A. Structure of D-3-hydroxybutyrate dehydrogenase prepared in the presence of the substrate D-3-hydroxybutyrate and NAD+. Acta Crystallogr Sect F Struct Biol Cryst Commun. 2009 Apr 1;65(Pt 4):331-5. doi: 10.1107/S1744309109008537. Epub 2009 Mar 26. PMID: 19342772; PMCID: PMC2664752.

[8] Machado, T. F., Purg, M., Åqvist, J. & da Silva, R. G. (2021). Transition States for Psychrophilic and Mesophilic (R)-3-Hydroxybutyrate Dehydrogenase-Catalyzed Hydride Transfer at Sub-zero Temperatures. Biochemistry, 60(27), 2186-2194

[9] Omar, A., Zakaria, E. K., Norbert, L. & Mrsquo; Hammed, S. D. E. K. (2009). D-3-hydroxybutyrate oxidation in mitochondria by D-3-Hydroxybutyrate dehydrogenase in Tetrahymena pyriformis. African Journal of Biochemistry Research, 3(3), 029-036.

[10] Soto-Mota, A.; Norwitz, N.G.& Clarke, K. Why a d-_-hydroxybutyrate monoester? Biochem. Soc. Trans. 2020, 48, 51–59.

[11] Nielsen R, Møller N, Gormsen LC, Tolbod LP, Hansson NH, Sorensen J, Harms HJ, Frøkiær J, Eiskjaer H, Jespersen NR, Mellemkjaer S, Lassen TR, Pryds K, Bøtker HE, Wiggers H. Cardiovascular Effects of Treatment With the Ketone Body 3-Hydroxybutyrate in Chronic Heart Failure Patients. Circulation. 2019 Apr 30;139(18):2129-2141. doi: 10.1161/CIRCULATIONAHA.118.036459. PMID: 30884964; PMCID: PMC6493702.

[12] Nakamura, M. & Sadoshima, J. (2019). Ketone body can be a fuel substrate for failing heart. Cardiovascular research, 115(11), 1567-1569

[13] Walaa Fikry, M. E. (2017). Lactate dehydrogenase (LDH) as prognostic marker in acute leukemia

quantitative method. J. Blood. Disord. Transfus, 8, 1-8.

[14] Li C, Ye J, Chen Q, Hu W, Wang L, Fan Y, Lu Z, Chen J, Chen Z, Chen S, Tong J, Xiao W, Mei J, Lu H. Elevated Lactate Dehydrogenase (LDH) level as an independent risk factor for the severity and mortality of COVID-19. Aging (Albany NY). 2020 Aug 14;12(15):15670-15681. doi: 10.18632/aging.103770. Epub 2020 Aug 14. PMID: 32805722; PMCID: PMC7467395.

[15] Yamaguchi, S., Abe, M., Arakaki, T., Arasaki, O. & Shimabukuro, M. (2020). Prognostic value of lactate dehydrogenase for mid-term mortality in acute decompensated heart failure: a comparison to established biomarkers and brain natriuretic peptide. Heart, Lung and Circulation, 29(9), 1318-1327

[16] Ay, H., Arsava, E. M., & Sarıbas, O. (2002). Creatine kinase-MB elevation after stroke is not cardiac in origin: comparison with troponin T levels. Stroke, 33(1), 286-289.

[17] Carvalho, G., & Rassi, S. (2016). The prognostic value of CK-MB in Acute Myocardial Infarction in developing countries: a descriptive study. Angiology, 4(3).

[18] Thikra A. Allwsh; Mahmoud A. M. Fakhri; Mohammad A. Hamza (2012). Biochemical Study of Myeloperoxidase in Blood and it's Relation to Atherosclerosis. Rafidain Journal of Science, 23(6), 107-127. doi: 10.33899/rjs.2012.59635

[19] Aviram M, Hardak E, Vaya J, Mahmood S, Milo S, Hoffman A, Billicke S, Draganov D, Rosenblat M. Human serum paraoxonases (PON1) Q and R selectively decrease lipid peroxides in human coronary and carotid atherosclerotic lesions: PON1 esterase and peroxidase-like activities. Circulation. 2000 May 30;101(21):2510-7. doi: 10.1161/01.cir.101.21.2510. PMID: 10831526.

[20] Zhang, N., Aiyasiding, X., Li, W. J., Liao, H. H. & Tang, Q. Z. (2022). Neutrophil degranulation and myocardial infarction. Cell Communication and Signaling, 20(1), 1-23.

[21] Winterbourne, C.C., Vissers, M.C.& kettle, A.J. (2000)."myeloperoxidase". Curr. opin. Hematol.7(1):53-8.

[22] Davies, M. J. & Hawkins, C. L. (2020). The role of myeloperoxidase in biomolecule modification, chronic inflammation, and disease. Antioxidants & redox signaling, 32(13), 957-981

[23] Lau, D. & Baldus, S. (2006). Myeloperoxidase and its contributory role in inflammatory vascular disease. Pharmacology & therapeutics, 111(1), 16-26.

[24] Omran, M. M., Zahran, F. M., Kadry, M., Belal, A. A. & Emran, T. M. (2018). Role of myeloperoxidase in early diagnosis of acute myocardial infarction in patients admitted with chest pain. Journal of Immunoassay and Immunochemistry, 39(3), 337-347

[25] Tal S, Smirnoff P, Okon Y. Purification and characterization of D (-)-β-hydroxybutyrate dehydrogenase from Azospirillum brasilense Cd. Microbiology. 1990 Apr 1;136(4):645-9. https://doi.org/10.1099/00221287-136-4-645

[26] Fischbach F. (2000) ."A Manual of Laboratory and Diagnostic Test"." 6th ed. Lippincott Williams and

ISSN: 0005-2523
Volume 62, Issue 10, December, 2022

Wilkins, U.S.A. ,p: 472

[27] Richterich R.(1969)." Clinical Chemistry Theory and Practice " .S. Karger A.G. Basel, Switzerland, pp: 245-249 32.

[28] Scimone J. and Rothstein R (1978)." Laboratory Manual of Clinical Chemistry" . AVI Puplishing company . Inc., U.S.A., pp: 60,63

[29] Young, D. S., Pestaner, L. C. & Gibberman, V. (1995). Effect of drug on laboratory tests. Pharmacogenomics, 3(1), 89-98

[30] Bakker AJ, Mücke M. Gammopathy interference in clinical chemistry assays: mechanisms, detection and prevention. Clin Chem Lab Med. 2007;45(9):1240-3. doi: 10.1515/CCLM.2007.254. PMID: 17635066.

[31] Tomás M, Sentí M, García-Faria F, Vila J, Torrents A, Covas M, Marrugat J. Effect of simvastatin therapy on paraoxonase activity and related lipoproteins in familial hypercholesterolemic patients. Arterioscler Thromb Vasc Biol. 2000 Sep;20(9):2113-9. doi: 10.1161/01.atv.20.9.2113. PMID: 10978257.

[32] Kumar P, Pai K, Pandey HP, Sundar S. NADH-oxidase, NADPH-oxidase and myeloperoxidase activity of visceral leishmaniasis patients. J Med Microbiol. 2002 Oct;51(10):832-836. doi: 10.1099/0022-1317-51-10-832.PMID:12435061.

[33] Rodgers JL, Jones J, Bolleddu SI, Vanthenapalli S, Rodgers LE, Shah K, Karia K, Panguluri SK. Cardiovascular Risks Associated with Gender and Aging. J Cardiovasc Dev Dis. 2019 Apr 27;6(2):19. doi: 10.3390/jcdd6020019. PMID: 31035613; PMCID: PMC6616540.

[34] Gallucci, G., Tartarone, A., Lerose, R., Lalinga, A. V. & Capobianco, A. M. (2020). Cardiovascular risk of smoking and benefits of smoking cessation. Journal of thoracic disease, 12(7), 3866

[35] Csige, I., Ujvárosy, D., Szabó, Z., Lőrincz, I., Paragh, G., Harangi, M. & Somodi, S. (2018). The impact of obesity on the cardiovascular system. Journal of diabetes research, 2018..

[36] Lee G, Choi S, Kim K, Yun JM, Son JS, Jeong SM, Kim SM, Park SM. Association of Hemoglobin Concentration and Its Change With Cardiovascular and All-Cause Mortality. J Am Heart Assoc. 2018 Jan 29;7(3):e007723. doi: 10.1161/JAHA.117.007723. PMID: 29378732; PMCID: PMC5850255.

[37] Mishra, A. (2022). Cardiovascular complications of diabetes mellitus. Sage journals. Volume 15(6).

[38] Dalal, R., Bruss , Z. S. & Sehdev, J. S. (2021). Physiology, renal blood flow and filtration. In StatPearls [Internet]. StatPearls Publishing.

[39] Choi KM, Han K, Park S, Chung HS, Kim NH, Yoo HJ, Seo JA, Kim SG, Kim NH, Baik SH, Park YG, Kim SM. Implication of liver enzymes on incident cardiovascular diseases and mortality: A nationwide population-based cohort study. Sci Rep. 2018 Feb 28;8(1):3764. doi: 10.1038/s41598-018-19700-8.

[40] Jasim, R. F. & Allwsh, T. A. (2021). Effect of plasma isolated Orexin-A on the regulation of metabolites in male rats. Iraqi Journal of Veterinary Sciences, 35(3), 451-457.

[41] Chiu, S., Williams, P. T. & Krauss, R. M. (2017). Effects of a very high saturated fat diet on LDL particles in adults with atherogenic dyslipidemia: A randomized controlled trial. PloS one, 12(2):1-14.

[42] AL-Daghstani,M,A,H.(2012) .Biochemical Study of Myeloperoxidase in Blood and it's Relation to Atherosclerosis .Univ. of Mosul, Iraq.

[43] Sami, H. N. (2022). Biochemical Study Of Serum β-Hydroxybutyrate Dehydrogenase in β-Thalassemia. Univ. of Mosul, Iraq.

[44] Choudhury,M. and Devagourou, V. (2017). Clinics in Surgery Biomarkers of Atherosclerosis: Is the Evaluation Essential Preoperatively?. Clinics in Surgery.2.1657:1-5

[45] Aydin S, Ugur K, Aydin S, Sahin İ, Yardim M. Biomarkers in acute myocardial infarction: current perspectives. Vasc Health Risk Manag. 2019 Jan 17;15:1-10. doi: 10.2147/VHRM.S166157. PMID: 30697054; PMCID: PMC6340361.

[46] Merza, W. M., Abdul-Qahar, Z. H. & Alsharifi, Z. Transaminase and Creatinine Predict Diastolic and Systolic Dysfunction in Patients with Myocardial Infarction.

[47] Li, C., Yang, X.Q., An, J., Cheng, K., Hou, X.L., Zhang, X.S., Hu, Y.G., Liu, B., Zhao, Y.D. (2020). Red blood cell membrane-enveloped O2 self-supplementing biomimetic nanoparticles for tumor imaging-guided enhanced sonodynamic therapy. Theranostics, 10(2), 867-879. https://doi.org/10.7150/thno.37930.