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Research Article

The Significance of Albumin Concentration and Some of Its Altered Forms in Iraqi Patients with Chronic Hepatitis B Virus

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Abstract:

Background: The liver synthesizes albumin, a pivotal protein that accounts for approximately 60-65% of total plasma proteins. During ischemic attacks linked to oxidative stress, reactive oxygen species, and acidosis, albumin's properties undergo alterations. This leads to the generation of ischemia-modified albumin, characterized by a diminished metal-binding capacity, particularly for transition metals like copper, nickel, and cobalt.

Objectives: This study aimed to assess the significance of serum albumin and ischemia-modified albumin concentrations in Iraqi individuals with hepatitis B virus

Methods: A case-control study, including 50 patients with hepatitis B recruited from a Gastroenterology hospital in the Medical City/ Baghdad/ Iraq, was conducted from January to February 2023. The patients' group included males and females, ages 18 to 77 years, with a mean value of 44 years. Meanwhile, the study group consisted of 50 sex-matched normal healthy individuals. Albumin concentration was determined in the serum samples using a Biosystems kit, and ischemia-modified albumin concentration was measured through the albumin cobalt binding test. The ischemia-modified albumin/ [albumin] ratio and ischemia-modified albumin index were then calculated.

Results: lower serum albumin concentration was measured in the patients' group, while the mean value of ischemia-modified albumin concentration in the patients' group and healthy control was 0.466 ± 0.114 absorbance unit & 0.395 ± 0.070 absorbance unit, respectively, with a statistically significant increase ($P < 0.001$). The ischemia-modified albumin ratio in the hepatitis B patients and control groups was 0.172 ± 0.073 and 0.117 ± 0.050, respectively, showing a significant increase ($P < 0.001$). Additionally, the ischemia-modified albumin index in the patients and the control groups were 0.491 ± 0.167 & 0.390 ± 0.131, respectively, with a statistically significant increase ($p<0.001$) in the patients group.

Conclusion: In the patients' group with hepatitis B, serum albumin concentration decreased, while the levels of ischemia-modified albumin, ischemia-modified albumin ratio, and ischemia-modified albumin index increased. The elevation in ischemia-modified albumin, ischemia-modified albumin ratio, and ischemia-modified albumin index was more prominent in younger patients and those with albumin concentrations less than 4g/dl. Moreover, the prevalence of hepatitis B is higher in men compared to women.

Keywords: Albumin concentration; Chronic hepatitis B Virus; Ischemia modified albumin; Ischemia modified albumin index; Ischemia modified albumin ratio.

Introduction

Hepatitis B virus (HBV) infection is one of the widespread and most important public health problems worldwide (1). Globally, about 2 billion people have been infected with the hepatitis B virus, and about 5% of them have chronic infections (2). As a marker of active HBV infection; the seroprevalence of hepatitis B surface antigen (HBsAg), was previously reported to be 3.61% worldwide, this indicates that a substantial number of people are chronically infected with this virus (3). Due to the consequences of HBV infection, it is estimated that each year about 600,000 people die. In addition, according to statistics from the Iraqi Ministry of Health, the number of Iraqi individuals who were infected with viral hepatitis B in 2022 was 2040(4). Human Serum Albumin (HSA), a crucial protein synthesized in the liver, serves essential roles such as maintaining osmotic pressure & transporting various metabolites in the bloodstream (5). Additionally, HSA exhibits the ability to bind specific metals, including copper, cobalt, and nickel, via its amino-terminal end. It undergoes some alterations in its structure (post-translation modification). Under normal physiological conditions, such alteration is minimal (6) This leads to the imposition of a new concept known as effective albumin concentration, a term, that indicates that albumin concentration is reduced under some conditions such as disease, but also, its quality as well altered. These alterations are due to several reversible and nonreversible changes, which lead to changes in albumin properties as well as the structure and production of different albumin isoforms (7). Several

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factors including ischemic attacks associated with excess production of reactive
oxygen species (ROS). the presence of oxidative stress (OS), and acidosis (8) development induces such alteration and thus the production of such different isoforms (9) (10), in which IMA is considered the most important isoform (11) and (12). This isoform was reported as an oxidative stress marker (13). Under conditions of ischemic attacks associated with excess production of reactive oxygen species (ROS), oxidative stress, and acidosis development,certain alterations in albumin properties occur (14). Among these alterations, the N-terminal sequence (Asp1-Ala2-His3-Lys4) of (HAS) is highly susceptible to certain biochemical modifications and degradation induced by oxidative stress. This leads to a reduction in the affinity of the N-terminal sequence towards cobalt, resulting in a variant of albumin known as ischemia-modified albumin (IMA) (9). Various models have been proposed to explain the formation of IMA, according to one of them, the α-amino group of Asp1 exhibits nucleophilic properties, leading to a nucleophilic attack on the peptide bond between Ala2 and His3, which results in the cleavage and release of a cyclic dipeptide. This truncated albumin is unable to bind transition metal ions (14). Another model suggests that during ischemia and acidosis, release of Cu^{2+} from weak binding sites occurs, and in the presence of reducing agents, such as ascorbic acid, free Cu^{2+} is converted to Cu^{+}, which reacts with O_2 to generate superoxide radicals. The albumin N-terminus scavenges these ions, forming hydrogen peroxide (H2O2) and subsequent production of hydroxyl-free radicals. This process causes damage to HSA, leading to the removal of two, or three of the amino acids at the N-terminal end and the release of Cu^{2+}. This chain reaction is repeated resulting in a rapid increase in IMA concentration following an ischemic attack (14) Recently the parameters: ischemia-modified albumin ratio (IMAR) and ischemia-modified albumin index (IMA index), have been introduced to compensate for the albumin concentration effect (15). In this context, this study aimed to compare the significance of albumin concentration, [IMA], IMAR, as well as IMA index in Iraqi patients with hepatitis

Materials and Methods:

A case-control study consisted of 50 patients with hepatitis B and 50, age and gender-matched healthy individuals as control. Blood samples were collected from patients who were attending Gastroenterology Hospital in the Medical city/ Baghdad/ Iraq, during the period from January to February 2023. The study Participants were both males and females, whose ages ranged from 18 to 77 years with a mean value equal to 44 years. Patients who had any type of infection other than chronic virus B, or had any other disease such as heart disease, diabetes mellitus, liver cirrhosis, or alcohol drinkers, smokers, and drug users were excluded from the study. The individual diagnosis testing kit (cat. No: vc010503, Sure Biotech (USA) co., ltd) comprises a test cassette, a dropper, a buffer, and a package insert. The cassette's test line region is precoated with antibodies against Hepatitis B surface antigen HBsAg. During the testing process, the serum specimen (or the whole blood) interacts with particles coated with anti-HBsAg antibodies. Through capillary action, the mixture migrates upward on the chromatographic membrane, reacting with anti-HBsAg antibodies on the membrane to produce a visible colored line. The presence of this colored line in the test region signifies a positive result, while its absence indicates a negative result. As a procedural control, a colored line always appears in the control line region, confirming that the correct specimen volume has been added. The diagnosis was also confirmed by the specialist at the same hospital from where the blood samples were collected for detection of the viral RNA in the blood using a PCR device and some biochemical enzymatic parameters including alanine aminotransferase (ALT) activity, aspartate aminotransferase (AST) activity, and alkaline phosphatase (ALP) activity. Blood samples of the patients and healthy individuals were subjected to centrifuge to obtain serum to conduct laboratory tests including measurement of the concentration of albumin and IMA. The albumin concentration was measured using the Biosystems kit (cat. No: b012139 Biosystem S.A. Costa and Spain) based on the reaction of bromocresol green with albumin and the formation of a colored product which was measured at ƛ= 630nm. A laboratory procedure based on the method mentioned (16) was used to determine the concentration of serum IMA. In this procedure, a volume (120 microliters) of cobalt dichloride reagent was added to the serum (35 microliters), and then the mixture was incubated for five minutes. During this incubation period, binding between the cobalt and the N- N-terminal of unmodified albumin occurred. To remove the unbound cobalt, a volume (35 microliters) of dithiothreitol reagent (DTT) was added resulting in color development. The change in the color was followed using ƛ= 480 nm and the IMA value was expressed in absorbance units (ABSU). IMA ratio (IMAR) was calculated as follows (17). IMAR = IMA absorbance/Alb. concentration While the IMA index was calculated as follows [16]: Individual [IMA] × individual Albumin concentration

$$\text{IMA index} = \frac{\text{Individual [IMA]} \times \text{individual Albumin concentration}}{\text{Median albumin concentration}}$$

Statistical Analysis: The GraphPad prism 9.5.1 (733) program (t-test, One-Way ANOVA, and Pearson correlation) was used to analyze the obtained results and to perform the correlation relationships, respectively. Throughout this work, the obtained results were reported as a mean value ± standard deviation. The differences were considered highly significant if ($p < (0.001)$ ***), and significant where ($p = (0.002)$ **) and ($p = (0.033)$ *)

Results:

The general characteristics of the individuals enrolled in the current study are shown in Table 1.

Table 1: Demographic characteristics and laboratory data of the studied groups

		Control group	Patient group	P value
Number		50	50	
Age/year	Total range (18-77)	41.800± 14.400	44.000± 15.307	<0.999
	range (18-50)	33.733± 6.313 (n=30)	34.867± 8.476 (n=30)	0.559
	range (51-77)	63.615±7.206 (n=9)	65.111± 6.900 (n=9)	0.632
Male	Percentage (number)	34 (17)	79.5 (31)	
	Age range /year	44.180± 9.665	48.118±14.115	0.351
Female	Percentage (number)	66 (33)	20.5 (8)	
	Age range	49.125±19.838	43.000±18.134	0.530
ALT (U/L)		19.940±15.330	46.350± 49.850	<0.001
AST (U/L)		23.130± 9.070	36.550± 32.230	0.008
ALP (U/L)		195.820± 59.900	129.228±72.660	<0.001
(PCR)		-	+	

The values were expressed as mean value ± S.D.

ALT: alanine aminotransferase activity. AST: aspartate aminotransferase activity. ALP: alkaline phosphatase activity. PCR: Polymerase Chain Reaction Test.

As it is clear from the above results the levels of ALT, and AST activities were significantly elevated (P<0.001, P=0.008) respectively in the patients as compared with the controls, while those of ALP activity were reduced. The changes in these enzymatic activities were used to confirm the infection of the patients' group with hepatitis B and this was based on (18). The levels of albumin concentration in the patients' group and the healthy controls were 2.985± 0.891 g/dl and 3.694± 0.972 g/dl respectively with significantly lower concentrations in the patients (P<0.001), while the levels of IMA, IMAR, and IMA index were 0.466± 0.114 and 0.395± 0.070, 0.171± 0.073 and 0.117± 0.777, 0.491± 0.167 and 0.390± 0.131 with a significant elevation (P<0.001) in the patients as compared with the controls. Both controls and patients with hepatitis B groups were separately divided, based on serum albumin concentration, into two groups: those with [Albumin] < 4g/dl and those with [Albumin] > 4g/dl. The obtained results are shown in **Table** 2.

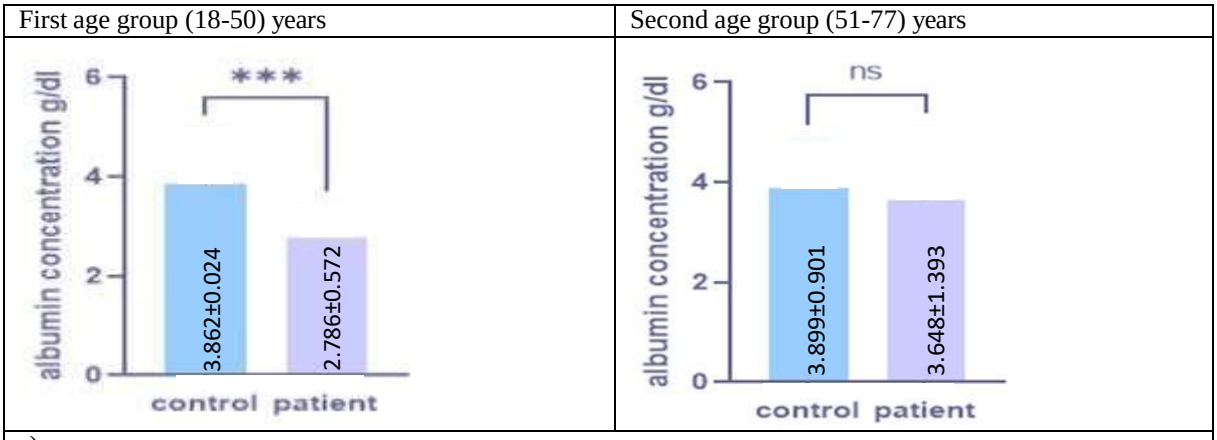
Table 2: Comparison of the levels of IMA, IMAR, and IMA index between patients and control groups according to albumin concentration.

	Albumin concentration < 4 g/dl		P value	Albumin concentration>4 g/dl		P value
	Control group	Patient group		Control group	Patient group	
IMA (ABSU)	0.388± 0.062	0.470± 0.121	<0.001	0.377± 0.045	0.436± 0.046	0.077
IMAR	0.124± 0.025	0.184± 0.071	<0.001	0.085± 0.016	0.091± 0.013	0.484
IMA index	0.331± 0.076	0.454± 0.137	<0.001	0.451± 0.049	0.748± 0.126	0.001

The values were expressed as mean value ± S.D.

The above results illustrated that the level of IMA, IMAR, and IMA index were significantly higher (P<0.001) in the patient group as compared with that in the controls. When the albumin concentration was < 4 g/dl there were no significant variations in IMA and IMAR levels between the controls and patients when the albumin concentration was >4g/dl, except in the IMA index which was statistically increased (P=0.001).

In this study, the controls and the patients were divided into two groups based on age. The first group consisted of 30 people aged between 18 and 50 years, and the second group consisted of 9 people aged between 51 and 77 years. The results of the IMA, IMAR, and IMA index are shown in Figure 1.



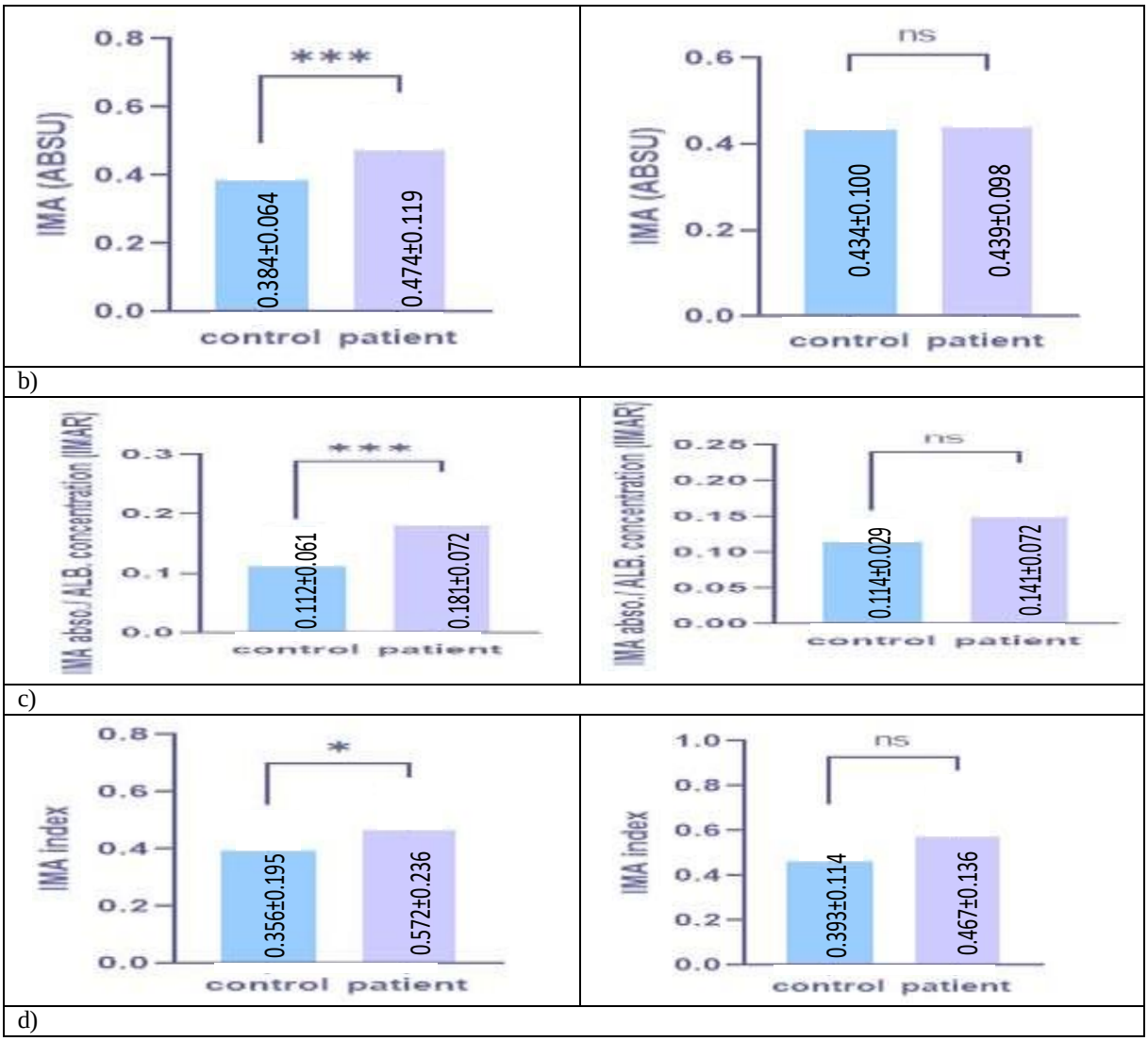


Figure 1: Comparison of the: a): albumin concentration, b): IMA, c): IMAR, and d): IMA index in the hepatitis B patients according to age. ns refer to non-significant. *: The difference is significant at P <0.05 level. ***: The difference is highly significant at the P<0.001 level.

It can be observed from these results that the level of albumin concentration was significantly lower (P<0.001), while the levels of IMA, IMAR, and IMA index were higher in patients as compared with the controls (P<0.001) for IMA, IMAR, and P=0.028) for IMA index in the first age group (18- 50 year). In the meantime, there were no observed significant variations in albumin concentration, IMA, IMAR, and IMA index (P=0.644, P=0.236, P=0.158, and P=0.657) respectively in the second age group (51- 77 years). The patients' group was divided based on gender and the obtained results of all measured parameters are shown in Table 3.

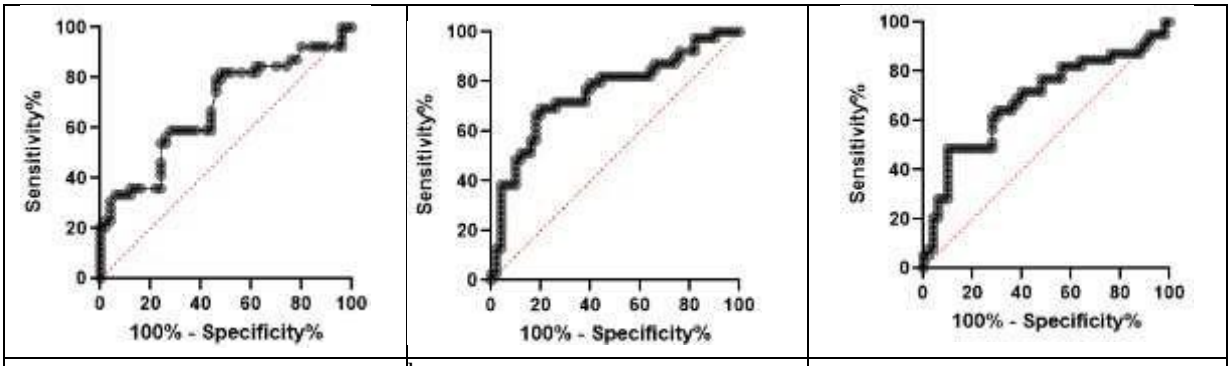
Table 3: Comparison of the albumin concentration, IMA, IMAR and IMA index in the hepatitis B patients according to their gender distribution.

	Male	Female	P value
Percentage (Number)	79.5% (n=31)	20.5% (n=8)	
Age/ year	48.118± 14.115	43.000±18.134	0.569
Albumin (g/dl)	3.143± 0.833	2.368± 0.830	0.024
IMA (ABSU)	0.472± 0.113	0.454± 0.133	0.568
IMAR	0.162± 0.060	0.216± 0.101	0.032
IMA index	0.525± 0.155	0.384± 0.181	0.168

The values were expressed as mean value ± S.D.

As it is clear from the above results in the hepatitis B female, the albumin concentration decreased significantly (P= 0.024) in comparison with that of male patients and the IMAR significantly increased as compared with that of male patients (P= 0.032). Meanwhile, there was no observed significant variation in IMA and IMA index as shown in Table 3

Receiver operating characteristic (ROC) curves analysis for IMA, IMAR & IMA index in the chronic hepatitis B patients' group, and the computed area under the curve (AUC) was found to be 0.6851 (95% CI: 0.5722– 0.7980) for IMA and its specified cut-off value of > 0.4550 revealed 43.59% sensitivity and 76% specificity. However, ROC analyses for IMAR revealed that the computed AUC was 0.7579 (95% CI: 0.6539– 0.8620), and for the specified cut-off value was > 0.1644 with the calculated sensitivity and specificity were 41.03% and 90%, respectively. Furthermore, the ROC analyses for the IMA index revealed that the computed AUC was 0.6877 (95% CI: 0.5725– 0.8029), and for the specified cut-off value of >0.7055 and the calculated sensitivity and specificity were 10.26% and 96%, respectively. The curves for IMA, IMAR, and IMA index are summarized in Figure 2.



a. b. c.

Figure 2: ROC curves (a) for IMA in the patients (n=39). (b): for IMAR in the patients (n=39). (c): for IMA index in the patients (n=39).

The effect of the entecavir (Figure 3) treatment on the level of albumin, IMA, IMAR, and IMA index was tested using 11 patients, who were under this Table **4**. These results showed that the entecavir drug had non-significant effects on the level of IMA, IMAR, and IMA index.

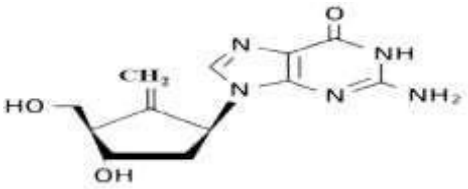


Figure 3: The chemical structure of entecavir.

treatment at a dose of 0.5 mg once a day orally and compared with those without treatment and results were shown in

Table 4: Comparison of IMA, IMAR, IMA index, and Albumin level in patients with treatment and those without treatment.

	Control group	Patient without treatment	Patient with treatment	P value between control and patient without treatment	P value between control and patient with treatment	P value between patient with treatment and without treatment
Number	11	11	11			
Age (year)	48.818±17.429	47.363±14.580	46.909±16.040	0.837	0.792	0.946
Albumin concentration mg/dl	3.837±0.553	2.828±1.036	2.772±0.497	0.010	<0.001	0.873
IMA (ABSU)	0.415±0.070	0.464±0.117	0.441±0.087	0.247	0.448	0.610
IMAR	0.113±0.026	0.189±0.099	0.163±0.041	0.019	0.002	0.440
IMA index	0.438±0.115	0.461±0.185	0.439±0.134	0.611	0.826	0.753

Values were expressed as mean value ± S.D.

Discussion:

The present study covered the variations in the albumin and IMA concentration in hepatitis B infected Iraqi patients, Human serum albumin is the most abundant circulating protein in the plasma (19)

The hypoalbuminemia recorded in the present study may be due to the decrease in the synthesis of albumin as a result of liver parenchymal failure (12), (13) Meanwhile, synthesis of this protein, which is one of the phase proteins, has been reported to be inhibited

by the presence of acidosis (chronic, but not acute), and by proinflammatory cytokine (20), (21).

Furthermore, the balance between albumin synthesis, catabolism, its intravascular and interstitial compartments intestinal exchange, or its renal loss, determines its concentration in the blood plasma (22), (7). The observed increase in the level of IMA in HBV Iraqi patients in the present research may be a result of the presence of chronic oxidative stress in hepatitis B patients. The measured elevation in IMA concentration agreed with (18) who reported in their studies in different HCV patients and agreed with (21) in their study on chronic liver disease in Turkish patients and with coronary collateral circulation in Chinese patients (7). Also, the measured elevated IMA in the present study patients agreed with the results of a study about acute ischemic stroke (7). Furthermore, Jagiełło (2012) reported that the high concentration of IMA might indicate chronic oxidative stress in chronic hepatitis C infection associated with metabolic complications (13). The reported high IMA level in HBV patients in the present study may be due to the increased formation of free radicals which causes oxidative damage to albumin N-terminal residues. Moreover, it may be due to changes in the liver microenvironment resulting from an inflammation caused by the viral infection. IMA was suggested to be a parameter that assesses albumin function (14).

Furthermore, it was reported to be affected by the level of albumin, hence it was suggested that IMAR and IMA index are more valuable indicators than IMA alone (13). Therefore, they were introduced as biochemical parameters to eliminate the albumin-level effect (23). In the current study, these two parameters were found to be elevated in HBV Iraqi patients. IMAR and IMA were also reported to reflect liver excretory function (14) and the observed elevation in IMAR not only reduces the effective circulating volume that is associated with the decreased albumin concentration in blood plasma but also indicates a reduction of the toxic metabolites such as bile acids, fatty acids, tryptophan… etc., removal from the blood because of the impairment in albumin binding capacity (25). Such reduction in albumin binding capacity results in the circulation of the waste products in their free forms which lead to their random reactions, instead of being delivered for clearance in a specific site. Both this deficiency in albumin's functional capacity to remove different toxins, as well as act as an efficient antioxidant predispose to liver function decompensation as a result of the disturbance in the live (25) (26).

The results of variations in the measured biochemical parameters according to the gender of the patients agreed with the result of (27) in their study on Nigerian patients with hepatitis C and (22) in their study on coronary disease. The higher prevalence of HBV among the males compared with females included in the current research may be explained by the higher possibility of men's exposure to viral infection than women. This finding could be in general, due to the fact that men are being employed to perform many activities outside their households (27). In this study, in order to look up if the variations in the measured biochemical parameters were affected by the patient's age, he present research results indicated that this type of infection was higher in the younger ages than in the elderly ones. These results agreed with the results of (28) in their study on Pakistani Patients with hepatitis B and are comparable with what was reported in central Nigeria patients with hepatitis B (29). The application of entecavir as a treatment regimen had no effect on the present study's measured parameters. This drug is known to affect HBV replication (30) The obtained results with this type of treatment may be due to the short period used for the treatment, which resulted in a non-observed effect of this type of treatment on either albumin concentration, or its measured related parameters in the current studied patients, or it may be due to that the impairment in the function of albumin in HBV patients was irreversible.

Limitations: The numbers of females and males were unequal, and there was an unbalanced distribution of age. This lead**s** to considering the present study results regarding these factors, as a pilot one which led to the statistical power of these factors on the present obtained results being limited

Conclusion:

The non-significant variations were obtained when the measurement results were analyzed according to gender, elderly age, and the effect of entecavir treatment were based on comparative samples of a small population, the number**s** of female**s** and males were unequal, as well as unbalanced distribution of age. This lead**s** to considering the present study results regarding these factors, as a pilot one which lead to the statistical power of these factors on the present obtained results were limited. Meanwhile, the ROC analysis pointed out to high specificity of each IMA, IMAR, and IMA index with low sensitivity and IMAR may be a promising advantage for liver function tests in patients with chronic HBV.

Authors' declaration:

We confirm that all the Figures and Tables in the manuscript belong to the current study. Besides, the Figures and images, which do not belong to the current study, have been given permission for re-publication attached to the manuscript. Authors sign on ethical consideration's Approval-Ethical Clearance: The project was approved by the local ethical committee in (Gastroenterology Hospital in the Medical City/ Baghdad/ Iraq) according to the code number (CSEC/1223/0139) on (1/ 1/ 2023).

Conflicts of Interest: None

Funding: None

Author contributions:

Study conception & design: (Zahraa Faris and Hathama Razooki Hasan). Literature search: (Zahraa Faris and Hathama Razooki Hasan). Data acquisition: (Zahraa Faris). Data analysis & interpretation: (Zahraa Faris and Hathama Razooki Hasan). Manuscript preparation: (Zahraa Faris and Hathama Razooki Hasan). Manuscript editing & review: (Zahraa Faris and Hathama Razooki Hasan).

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اهمية تركيز الألبومين وبعض أشكاله المتغيرة لدى المرضى العراقيين المصابين بفايروس التهاب الكبد ب الوبائي المزمن

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الخلفية: يقوم الكبد بتخليق الألبومين، وهو بروتين محوري يشكل حوالي 60-65% من إجمالي بروتينات البلازما. أثناء النوبات الإقفارية المرتبطة بالإجهاد التأكسدي وأنواع الأوكسجين الفعالة والحامضية، تخضع خصائص الألبومين لتغييرات. تؤدي إلى توليد الألبومين المعدل بالاقفار، والذي يتميز بانخفاض قدرة الارتباط بالمعادن، خاصة بالنسبة للمعادن الانتقالية مثل النحاس والنيكل والكوبالت.
هدف الدراسة: هدفت هذه الدراسة إلى تقييم تراكيزالألبومين والألبومين المعدل بالاقفار (IMA) لدى الأفراد العراقيين المصابين بفيروس التهاب الكبد ب(HBV) .
الطرائق العمل: شملت دراسة الحالة- السيطرة 50 مريض مصاب بالتهاب الكبد الوبائي ب المزمن
تم جمع نماذج الدم منهم اثناء مراجعتهم مستشفى أمراض الجهاز الهضمي في مدينة الطب في بغداد، العراق، خلال الفترة من كانون الثاني إلى شباط من عام 2023 . وشملت مجموعة المرضى ذكور واناث تراوحت أعمارهم بين 18 سنة إلى 77 سنة بمتوسط عمر 44 سنة. تم أيضا جمع 50 افراد اصحاء متوافقين بالعمر والجنس مع مجموعة الدراسة لاستخدامهم كسيطرة. تم تحديد تركيز الألبومين في المصل باستخدام عدة Biosystem ، وتم قياس تركيز الالبومين المعدل بالاقفار في المصل من خلال اختبار ربط الكوبالت بالألبومين. وتم حساب نسبة الالبومين المعدل بالاقفار/الألبومين (و نسبة الالبومين المعدل بالاقفار) ومؤشر الالبومين المعدل بالاقفار.
النتائج: وجدت تراكيز واطئة للالبومين في مصول المرضى مما في مجموعة السيطرة وكان متوسط تراكيزال الالبومين المعدل بالاقفار في مجموعة المرضى والسيطرة الاصحاء 0.466 ± ABSU 0.114 و 0.395 ± ABSU 0.070، على التوالي، مع زيادة ذات دلالة معنويةإحصائيا (P <0.001).و كانت ال نسبة الالبومين المعدل بالاقفار في مرضى التهاب الكبد الفايروسي ب ومجموعة السيطرة مساوية الى 0.172 ± 0.073 و 0.117 ± 0.050 على التوالي، مما يدل على زيادة كبيرة أيضا (P <0.001). بالإضافة إلى ذلك، كان مؤشر الالبومين المعدل بالاقفار في المرضى ومجموعة السيطرة 0.491 ± 0.167 و 0.390 ± 0.131، على التوالي، مع زيادة ذات دلالة معنوية إحصائيا (P <0.001).
الاستنتاج: في مجموعة المرضى المصابين بالتهاب الكبد الفايروسي ب المزمن، انخفض تركيز الالبومين في الدم، في حين ارتفع مستوى الالبومين المعدل بالاقفار، نسبة الالبومين المعدل بالاقفار، ومؤشر الالبومين المعدل بالاقفار. كان الارتفاع في مؤشر الالبومين المعدل بالاقفار، نسبة الالبومين المعدل بالاقفار، ومؤشر الالبومين المعدل بالاقفار أكثر وضوحا في المرضى الأصغر سنا والذين لديهم تركيز الألبومين أقل من 4 ملي غرام / 100 مليلتر. علاوة على ذلك، كان معدل انتشار التهاب الكبد الفايروسي ب أعلى بين الرجال مقارنة بالنساء.

الكلمات المفتاحية: تركيز الألبومين، فيروس التهاب الكبد ب المزمن، الالبومين المعدل بالاقفار، مؤشر الالبومين المعدل بالاقفار، نسبة الألبومين المعدل بالاقفار.