An existence of complex interrelations among hypertriglyceridemia, type II diabetes mellitus, hypercholesterolemia and dyslipidemia is well documented. This may suggest that a well prepared study is an urge to define clearly these interrelations among those different mentioned terms and then expand the study to find out their effect on the liver enzyme ALT (Alanin Amino transferase) through its association with Nonalcoholic fatty liver disease. The study is conducted in four parts, each will discuss one issue that is declared through measuring: The effect of high serum Triglyceride and Cholesterol on Glucose elevation in human serum. The effect of high serum Cholesterol and Glucose on Triglyceride elevation in human serum. The effect of high serum Triglyceride and Glucose on Cholesterol elevation in human serum. ALT elevation in association with Triglyceride, Cholesterol and Glucose elevation in human Serum. This book is prepared for those in the medical field interested in finding out better understanding to these deep interrelations among glucose, cholesterol, and Triglyceride elevations and how they can be associated with each other.

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978-3-659-18231-0

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Associations, Correlations and Interrelations

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Impressum / Imprint
Bibliografische Information der Deutschen Nationalbibliothek: Die Deutsche Nationalbibliothek verzeichnet diese Publikation in der Deutschen Nationalbibliografie; detaillierte bibliografische Daten sind im Internet über http://dnb.d-nb.de abrufbar.

Bibliographic information published by the Deutsche Nationalbibliothek: The Deutsche Nationalbibliothek lists this publication in the Deutsche Nationalbibliografie; detailed bibliographic data are available in the Internet at http://dnb.d-nb.de.

Coverbild / Cover image: www.ingimage.com

Verlag / Publisher:
LAP LAMBERT Academic Publishing
ist ein Imprint der / is a trademark of
AV Akademikerverlag GmbH & Co. KG
Heinrich-Böcking-Str. 6-8, 66121 Saarbrücken, Deutschland / Germany
Email: info@lap-publishing.com

Herstellung in Deutschland (siehe letzte Seite) /
Printed in the U.S.A. / U.K. by (see last page)
ISBN: 978-3-659-18231-0

Hypertriglyceridemia, type II diabetes mellitus and Hypercholesterolemia. Correlations and Interrelations

A THESIS TO EARN MASTER DEGREE IN CLINICAL CHEMISTRY

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بسم الله الرحمن الرحيم

وقل رب زدني علما

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Introduction: Previous studies have demonstrated that high serum triglyceride has a well-established impact on increasing cases of *high glucose levels in blood*. Meanwhile, elevation in serum cholesterol alone does not have the same impact on increasing cases of high glucose levels in human blood. Both elevation in triglyceride and cholesterol similtinuasly, has a strong impact on increasing cases of elevated glucose in blood and thus has a strong effect on *diabetes*. Studies concluded that decreasing serum Lipids and triglyceride concentration will decrease blood glucose in human body. Prevention of diabetes complications is achieved by controlling among other factors serum lipids. In patients with type II diabetes mellitus a goal of low-density lipoprotein cholesterol of less than 200 mg/dL and triglycerides lower than 130 mg/dL should be sought.

On the other hand the studies indicated that the most common abnormality in diabetes mellitus is *hypertriglyceridemia*. Hypertriglyceridemia is associated with increased synthesis and decreased degradation of very low density lipoproteins (VLDL) and triglyceride. Diet rich in glucose caused a prolonged elevation in serum triglyceride for a long time. Type II diabetes revealed that, those patients do have problems in lipids concentration and metabolism. Lipid toxicity would not occur without blood glucose elevation. Lipids and glucose toxicity are interrelated and glucose effect on lipids metabolism is essential, so that lipids toxicity is to be understood as part of glucose toxicity. Blood hypercholesterolemia was associated with blood hypertriglyceridemia, which meant that both cholesterol and triglyceride elevation are not independent of each other. Significant elevation in blood glucose and serum triglyceride was noticed after 30-60-150 minutes of the glucose rich drink consumption and jogging.

In a study titeled : "Lipid and lipoprotein profiles in Ethiopian patients with diabetes mellitus", *hypercholesterolemia* and hypertriglyceridemia were found in 47.3% and 41.8% of patients with diabetes mellitus compared with 27% and 17% in normal controls. High density lipoprotein level(HDL) is decreased in patients with diabetes. Diabetes has a known effect on cholesterol metabolism. This effect is independent of the associated Hyperlipidemia. The study also indicated that the synthesized and absorbed cholesterol was similar among diabetic and non-diabetic patients involved in the study. No direct association existed between cholesterol absorption, synthesis, and excretion and blood glucose levels. Other statistical studies indicated that 69% of type II diabetes had a significant elevation in cholesterol.

The liver produces triglycerides and changes some into cholesterol. The elevation in cholesterol syntheses in diabetics was due to the hyperlipidemia and more specifically due to hypertriglyceremia associated with triglyceride elevated in the serum. Cholesterol synthesis and degradation is affected by VLDL and triglyceride metabolism. Blood hypercholesterolemia is associated with blood hypertriglyceridemia, which means that both cholesterol and triglyceride elevation are not independent of each other.

Lastly, *obesity* is a major health problem worldwide. Obesity increases the risk of developing several chronic diseases such as type 2 diabetes, insulin resistance, high blood pressure, and *nonalcoholic fatty liver disease* (NAFLD). 80% of type II diabetes patients are over weight. Nonalcoholic fatty liver disease is associated with insulin resistance. Fatty liver or NASH (Nonalcoholic steatohepatitis) is very common among overweight persons over the age of 30. Fatty liver contains an excessive amount of fat. In such a liver, liver cells and the spaces in the liver are filled with fat so the liver becomes slightly enlarged and heavier. There may also be elevation of the liver enzymes. More than 70 percent of people with nonalcoholic steatohepatitis (NASH) are obese. As many as three out of four people with NASH also have diabetes. High cholesterol levels and elevated triglycerides are common in people who develop NASH. It's estimated that up to 80 percent of people with NASH have hyperlipidemia.

These complex interrelations among hypertriglyceridemia, type II diabetes mellitus and hypercholesterolemia and dyslipidemia in the other hand may suggest that a well prepared study is considered as an urge to define clearly these interrelations among those different mentioned terms and then expand the study to find out their effect from the biochemical point of view on the liver enzyme ALT (Alanin Amino transferase) through its association with Nonalcoholic fatty liver disease.

The study is conducted in four parts, each will discuss one issue that is declared by the corresponding title:

1- A study measures the effect of high serum Triglyceride and Cholesterol on Glucose elevation in human serum.

2- A study measures the effect of high serum Cholesterol and Glucose on Triglyceride elevation in human serum.

3- A study measures the effect of high serum Triglyceride and Glucose on Cholesterol elevation in human serum.

4- A study of ALT Elevation in Association with Triglyceride, Cholesterol and Glucose Elevation in Human Serum.

A study measures the effect of high serum Triglyceride and Cholesterol on Glucose elevation in human serum

Abstract

Objectives: The purpose of this study is to further confirm the results documented in previous studies and to test the hypothesis of the presence of any correlation and if found, the regression nature of such correlation between triglyceride and glucose levels in one hand and cholesterol and glucose levels in the other hand.

Methods: Samples were collected between March and August 2009 from 438 of both males and females from two patient groups; a) nondiabetic patients, b) non-insulin dependent type II diabetic patients.

The patients' serum glucose; cholesterol and triglyceride were simultaneously determined. A comparison study was conducted on the effect of the elevated level of each of the parameters (Cholesterol and Triglyceride) on glucose elevation.

Results: The results showed that there was a significant difference in the number of cases with high glucose values >110 mg/dl among the three different study groups. There was a significant difference in the number of cases with glucose values >110 mg/dl between the two different study groups; 1) triglyceride <151 mg/ dl and cholesterol >201 mg/dl, 2) triglyceride >151 mg/dl and cholesterol>201 mg/dl.

Conclusion: The elevation in triglyceride but not cholesterol has the same effect of both triglyceride and cholesterol elevation together on the association with increasing levels of high glucose in blood.

Keywords: Glucose; Cholesterol; Triglyceride; Association

Introduction:

In previous studies measuring the effect of high serum triglyceride and cholesterol on glucose elevation in human serum, It was demonstrated that high serum triglyceride has a well-established association and impact on increasing cases of high glucose levels in blood (*1,*2,*3,*4), while elevation in serum cholesterol alone has no real association or impact on increasing cases of high glucose levels in human blood (*3).

Glucose, Cholesterol and Triglyceride, The interrelations and correlations:

Most of the studies done on glucose have mentioned that 90-95% of the diabetes cases were type II diabetes mellitus. This adult type diabetes affects older people who are obese or over weight, or have a family history with diabetes, and are with a restricted movement or limited exercise. Type II diabetes mellitus is more frequent in some human races who inherit the disease. 80% of type II diabetes patients are over weight. In a primary study on 3000 human individuals who are on their preliminary stages of the diabetes symptoms, the results showed that decreasing weight between 5-7% on those individuals who participated in the study had protected 60 % of the participants from developing real diabetes. Their behavior in decreasing their weight achieved by stop consuming fats and exercising. The studies on type II diabetes revealed that, those patients do have problems in lipids concentration and metabolism (*5). It was concluded that decreasing serum Lipids and triglyceride concentration will decrease blood glucose in human body.

In a study monitoring belongs to lipids toxicity (*6), the results revealed that hpertriglycemia is essential for lipid toxicity to develop. Lipid toxicity would not occur without blood glucose elevation. While glucose toxicity has a separate mode of action from lipids elevation, and it does not require that serum lipids is being elevated. The study concludes that lipids and glucose toxicity are interrelated and that glucose effect on lipids metabolism is essential, so that lipids toxicity is to be understood as part of glucose toxicity.

In a third study evaluating sterol excretion and cholesterol absorption in diabetics and nondiabetics with and without hyperlipidemia). The results indicated that sterol excretion is elevated in those who are hyperlipidemic (*3). It was more elevated in those who had both diabetes with hyperlipidemia. Absorbed cholesterol and excretory sterol did not show any significant difference between diabetic or non-diabetic patients who had same serum triglyceride concentration. The study shows that the disturbance mostly associated with diabetes mellitus is hypertriglyceremia, which is associated with triglyceride and VLDL syntheses but not decomposition. The study also indicated that the synthesized and absorbed cholesterol was similar among diabetic and non-diabetic patients involved in the study. The elevation in cholesterol syntheses in diabetics was due to the hyperlipidemia and more specifically due to hypertriglyceremia associated with triglyceride elevated in the serum. No direct association existed between cholesterol absorption, synthesis, and excretion and blood glucose levels.

While a study assessing lipids and carbohydrate metabolism in type II diabetic patients pointed out that a diet rich in glucose caused a prolonged elevation in serum triglyceride for a long time (*5).

Furthermore, a study conducted to determine the relationship of Obesity to Serum Triglyceride, Cholesterol, and Uric Acid, and to Plasma-Glucose Levels indicated that blood hypercholesterolemia was associated with blood hypertriglyceremia, which meant that both cholesterol and triglyceride elevation are not independent of each other (*7).

Moreover, a preliminary observation conducted to assess the Genetic Association Between Insulin Resistance And Total Cholesterol In Type 2 Diabetes Mellitus showed that 69% of type II diabetes had a significant elevation in cholesterol (*8).

Last, another study in Nigeria based on exercise performance in relation to glucose drink and their effect on some biochemical parameters, the study highlighted significant elevation in blood glucose and serum triglyceride was noticed after 30-60-150 minutes of the glucose rich drink consumption and jogging (*9).

This study is conducted to further confirm the results documented in the previous studies and to test the hypothesis of the presence of any correlation and if found, the regression nature of such correlation between triglyceride and glucose levels in one hand and cholesterol and glucose levels in the other hand.

Materials and Methods:

Samples were collected from patients who came to the laboratory located in the center of Damascus city during the date between March and August 2009. The sample was gathered from two patient types, the first is non-diabetic patients who came for general laboratory checkup, and the second is non-insulin dependent type-2- diabetic patients. The sample consisted of 438 of both males and females in age between 38-86 years who had their blood drawn and fasting serum glucose; cholesterol and triglyceride were similtinuasly determined. Dividing the study group in to different categories according to the levels of both cholesterol and triglyceride, the study considered the normal cholesterol level up to 200 mg/dl and the normal level of triglyceride up to 150 mg/dl. Moderate high level of cholesterol was considered 201-239 mg/dl and of triglyceride it was 151-200 mg/dl. The level of cholesterol > 239 and of triglyceride > 200 were considered to be very high levels.

A comparison study was conducted on the effect of the elevated level of each of the parameters (cholesterol and triglyceride) on glucose elevation as follows:

Study-1- measures the number of cases of high serum glucose > 110 mg/dl in the three different serum cholesterol and triglyceride groups: 1-(triglyceride<151 mg/dl, cholesterol<201 mg/dl), 2- (triglyceride 151-200 mg/dl, cholesterol 201-239 mg/dl), 3-(triglyceride >200 mg/dl, cholesterol>239 mg/dl).

Study-2- measures the number of cases of high serum glucose > 110 mg/dl in the two different serum cholesterol and triglyceride groups: 1-(triglyceride <151 mg/dl, cholesterol>200 mg/dl), 2- (triglyceride >150 mg/dl, cholesterol>200 mg/dl).

Study-3- measures the number of cases of high serum glucose > 110 mg/dl in the two different serum cholesterol and triglyceride groups 1-(triglyceride >150 mg/dl, cholesterol<201 mg/dl), 2- (triglyceride >150 mg/dl, cholesterol>200 mg/dl).

Study-4- measures the number of cases of high serum glucose > 110 mg/dl in the two different serum cholesterol and triglyceride groups 1-(triglyceride <151 mg/dl, cholesterol>200 mg/dl), 2- (triglyceride >150 mg/dl, cholesterol<201 mg/dl).

Study-5- measures the glucose mean and standard deviation under the following categories: 1- Individuals with normal triglyceride normal cholesterol. 2- High triglyceride normal cholesterol. 3-Normal triglyceride high cholesterol. 4- High triglyceride high cholesterol.

Study-6- measures both the correlation and the regression considering the cholesterol as the independent variable and the glucose as the dependant one.

Study-7- measures both the correlation and the regression considering the triglyceride as the independent variable and the glucose as the dependant one.

Analysis and results:

Table-1- Measuring the number of cases of high serum glucose > 110 mg/dl

between groups: 1-(triglyceride <151 mg/dl, cholesterol>200 mg/dl), and 2- (triglyceride >150 mg/dl, cholesterol>200 mg/dl).

Cholesterol Triglyceride mg /dl	Total number of cases studied	Number of High glucose cases >110 mg/dl	Expected # of cases with Glucose >110 mg/dl	Chi-Square value
Cho<201 Tg<151	160	27	36	12.45
Cho 201-239 Tg 151-200	46	12	10	
Cho>239 Tg>200	21	12	5	

Table-2- Measuring the number of cases of high serum glucose > 110 mg/dl between groups: 1-(triglyceride <151 mg/dl, cholesterol>200 mg/dl), and 2- (triglyceride >150 mg/dl, cholesterol>200 mg/dl).

Cholesterol Triglyceride mg /dl	Total number of cases studied	Number of High glucose cases >110 mg/dl	Expected # of cases with Glucose >110 mg/dl	Chi-Square value
Cho>200 Tg<151	77	17	27	6.133
Cho>200 Tg >150	120	51	41	

Table-3- Measuring the number of cases of high serum glucose > 110 mg/dl between groups: 1-(triglyceride >150 mg/dl, cholesterol<201 mg/dl), 2- (triglyceride >150 mg/dl, cholesterol>200 mg/dl).

Cholesterol Triglyceride mg /dl	Total number of cases studied	Number of High glucose cases >110 mg/dl	Expected # of cases with Glucose >110 mg/dl	Chi-Square value
Cho<201 Tg>150	81	38	36	0.1865
Cho>200 Tg >150	120	51	53	

Table-4- Measuring the number of cases of high serum glucose > 110 mg/dl between groups: 1-(triglyceride <151 mg/dl, cholesterol>200 mg/dl), 2-(triglyceride >150 mg/dl, cholesterol<201 mg/dl).

Cholesterol Triglyceride mg /dl	Total number of cases studied	Number of High glucose cases >110 mg/dl	Expected # of cases with Glucose >110 mg/dl	Chi-Square value
Cho<201 Tg>150	81	38	28	7.27
Cho>200 Tg <151	77	17	27	

Table (5): Measuring the glucose mean and standard deviation under the following categories: 1- Normal triglyceride normal cholesterol. 2- High triglyceride normal cholesterol. 3-Normal triglyceride high cholesterol. 4- High triglyceride high cholesterol.

Glucose	Normal triglyceride <151 mg/dl Normal cholesterol <201 mg/dl	High triglyceride >150 mg/dl normal cholesterol >200 mg/dl	Normal triglyceride high cholesterol	High triglyceride high cholesterol
# of patients	160	81	77	120
Average	102.8863	128.4568	106.0065	125.3292
STD	40.88006	63.45413	37.28786	46.77101

Table (6) Measuring both the correlation and the regression considering the cholesterol as the independent variable and the glucose as the dependant one.

	All the 438 individuals	: Cholesterol is normal<201 mg/dl	: Cholesterol is 201-239 mg/dl	: Cholesterol is >239 mg/dl
(r) (the correlation coefficient)	0.35	0.4	0.4	0.28

Regression P (slope)	0.19	0.28	0.116	0.27
S *y.x* (Standard error of estimate)	45.06	71.35	32.01	56.91
S*b* (Estimated standard error value	10.48	10.17	3.2	7.0
TR (The test ratio)	0.018	0.028	0.036	0.038
P (Pearson rho)	0.35	0.4	0.4	0.28

Table (7) Measuring both the correlation and the regression considering the triglyceride as the independent variable and the glucose as the dependant one.

	All the 438 individuals	: Triglyceride is normal<151 mg/dl	: Triglyceride is 151-200 mg/dl	: Triglyceride is >200 mg/dl
(r) (the correlation coefficient	0.095	0.075	0.040	-0.043
Regression P (slope)	0.12	0.089	0.045	-0.06

S *y.x* (Standard error of estimate)	47.93	39.67	41.41	44.34
S*b* (Estimated standard error value	26.34	18.37	11.17	13.5
TR (The test ratio)	0.0045	0.0050	0.0038	-0.0045
P (Pearson rho)	0.095	0.075	0.040	0.043

In the first four tables we used the Chi-Square test as a means of comparing the results according to the following null hypotheses: The total number of elevated cases of glucose values > 110 mg/dl in the different study groups is equal under 0.05 level of significance. Thus there is no significant difference in elevated glucose level among the different study groups in such case.

The alternative hypotheses: The total number of elevated cases of glucose values > 110 mg/dl in the different study groups is not equal under 0.05 level of significance. Thus there is a significant difference in elevated glucose level among the different study groups in such case.

We have chosen in our study to reveal the influence of both elevated serum triglyceride and cholesterol levels on glucose level in blood on a step by step basis starting in table-1- by checking the effect of elevation in both triglyceride and cholesterol together on glucose then moving a step forward in table-2- by checking the effect of triglyceride elevation while cholesterol is normal and comparing that with the effect of both high cholesterol and triglyceride. In table-3- we checked-in the effect of cholesterol elevation while triglyceride is normal and compared that with the effect of both high cholesterol and triglyceride. We decided in table-4- to compare the effect of high triglyceride normal cholesterol with the effect of high cholesterol normal triglyceride cases on the number of cases of high glucose levels in blood.

Table (1) indicates that 27/160 individuals in group –1- with their triglyceride<151 mg/dl and cholesterol<201 mg/dl are hyperglycemic. While with their triglyceride 151-200 mg/dl and cholesterol 201-239 mg/dl, 12/46 individuals in group –2- are hyperglycemic. And with their triglyceride >200 mg/dl and cholesterol>239 mg/dl, 12/21 individuals in group –3- are hyperglycemic. The Chi-Square value is 12.45> 5.99 (P< 0.05), hence and there is a significant difference in the number of cases with high glucose values > 110 mg/dl among the three different study groups.

Table (2) indicates that 17/77 individuals in group –1- with their triglyceride<151 mg/dl and cholesterol>201 mg/dl are hyperglycemic. While with their triglyceride >151mg/dl and cholesterol>201 mg/dl, 51/120 individuals in group –2- are hyperglycemic. The Chi-Square value is 6.133> 3.88 (P< 0.05), hence there is a significant difference in the number of cases with high glucose values > 110 mg/dl between the two different study groups.

Table (3) indicates that 38/81 individuals in group –1- with their triglyceride>151 mg/dl and cholesterol<201 mg/dl are hyperglycemic. While with their triglyceride >151mg/dl and cholesterol>201 mg/dl, 51/120 individuals in group –2- are hyperglycemic. The Chi-Square value is 0.186< 3.88 (P< 0.05) hence there is no significant difference in the number of cases with high glucose values > 110 mg/dl between the two different study groups.

Table (4) indicates that 17/77 individuals in group –1- with their triglyceride<151 mg/dl and cholesterol>201 mg/dl are hyperglycemic. While with their triglyceride >151mg/dl and cholesterol<201 mg/dl, 38/81 individuals in group –2- are hyperglycemic. The Chi-Square value is 7.27> 3.88 under the 0.05 level of significance, and there is a significant difference in the number of cases with high glucose values > 110 mg/dl between the two different study groups.

Meanwhile, in table (5) the mean and standard deviation were evaluated and found that in the 160 individuals with normal triglyceride <151 mg/dl and normal cholesterol <201 mg/d, the average glucose value was 102.89 mg/dl and the standard deviation was 40.88. The study also revealed that in the 81 individuals having high triglyceride >151 mg/dl and normal cholesterol <201 mg/d, the average glucose value was 128.46 mg/dl and the standard deviation was 63.45. And in the 77 individuals having normal triglyceride< 151 mg/dl and high cholesterol >201 mg/d, the average glucose value was 106.0 mg/dl and the standard deviation was 37.29. Also in the 120 individuals having high triglyceride> 151 mg/dl and high cholesterol >201 mg/d, the average glucose value was 125.33 mg/dl and the standard deviation was 46.77.

Further, the study in table (6) shows the presence of any correlation and hence, the regression considering the cholesterol as the independent variable and the glucose as the dependant one. The correlation coefficient value was 0.35 for all the 438 individuals that the study was conducted on. While with individuals having normal cholesterol<201mg/dl, the correlation coefficient value was 0.4 and with the group with cholesterol value 201-239 mg/dl, the correlation coefficient value was also 0.4 and with cholesterol value >239 mg/dl, the correlation coefficient value was 0.28. Likewise, the study in table (7) shows the presence of any correlation and hence, the regression considering the triglyceride as the independent variable and the glucose as the dependant one. The correlation coefficient value was 0.095 for all the 438 individuals that the study was conducted on. While with individuals having normal triglyceride <151mg/dl, the correlation coefficient value was 0.075 and with the group with triglyceride value 151-200 mg/dl, the correlation coefficient value was also 0.040 and with triglyceride value >200 mg/dl, the correlation coefficient value was -0.043.

In both tables 6 and 7, the t test studied the regression slope at 5% level of significance under the assumption that the slope of the samples according to the different categories presented above is zero. In the triglyceride case, the test ratio for the t test for the slope (TR) in all the different categories was< 0.04, which is very small to reject our assumption. Thus in all the cases, we accept our hypotheses that no true relationship exists between the elevation in serum triglyceride and the elevation in serum glucose in the same sample according to table (7). In other words, in each and every single sample, elevation in triglyceride does not necessarily, in the same manner, associate with the same level of glucose elevation when test is done on the same sample from the same patient. Likewise, according to table (6), no true forward or reverse relationship exists between the elevation in serum cholesterol and the elevation in serum glucose in every single sample when test is done on the same sample from the same patient. That means, high level of cholesterol does not have to be associated with the same high glucose level in the same sample.

Discussion:

This retrospective study aims at further identifying the real effect of the elevation of serum triglyceride and serum cholesterol separately or in combination, on glucose levels in blood. The results in table (1) reveals that the elevation in both triglyceride and cholesterol similtinuasly has a strong impact and association with increasing cases of elevated glucose in blood and thus has a strong effect on diabetes(*10). Table (2) declares that the difference is significant and hence the elevation in cholesterol alone does not have the same impact of the association of both triglyceride and cholesterol elevation on increasing cases of high glucose in blood (*3). The results in table (3) show no significant difference between the triglyceride elevation alone and the elevation in both triglyceride and cholesterol. Thus we conclude that elevation in triglyceride but not cholesterol has the same effect of both triglyceride and cholesterol elevation on the association with increasing cases of high glucose in blood. That last statement is confirmed by the results in table (4) where it shows a presence of a significant difference between the triglyceride elevation compared to the cholesterol elevation on the number of cases with high glucose levels in blood. So triglyceride elevation has more impact than cholesterol on cases of blood glucose elevation. To confirm our findings we tested in table (5) the average of serum glucose values under the four categories: normal triglyceride and cholesterol, normal triglyceride high cholesterol, high triglyceride normal cholesterol, high triglyceride high cholesterol. It is clear from the results presented that the average glucose value in the first and second categories did not exceed the normal glucose range, while it exceeded the normal value when serum triglyceride was elevated alone or together with cholesterol (*11).

Last in tables (6-7) we tested the correlation and regression values. It is obvious that cholesterol is more positively correlated with glucose when compared with triglyceride as we see from the cholesterol correlation coefficient values. They varied between 0.28 and 0.4 among the four different study groups. The correlation coefficient values for the triglyceride with glucose are only varying between -0.043 and 0.095.

Upon testing the hypothesis of a real forward or inverse relationship existence between the triglyceride and glucose or between cholesterol and glucose as for example, when one value of triglyceride goes up or down the corresponding glucose value goes in the same direction, we found that the TR value (the test ratio for the t test for slope) in the cholesterol groups ranging between 0.018 and 0.038 and for the triglyceride groups between - 0.0045 and 0.0045. In both cases the values are far bellow the boundaries of the rejection region so we accept our hypothesis: (the value of B which is the slope of each tested sample regression line is (0) and thus far, no forward or inverse relationship exists between serum triglyceride and serum glucose as a value to value, in the same sample in one hand or between serum cholesterol and serum glucose as a value to value, in the same sample in the other hand.

In conclusion: A strong association exists between both serum triglyceride and cholesterol elevation together and the increase cases of high blood glucose (*6). An association exists between serum triglyceride elevation and the increase cases of high blood glucose (*4). There is no association exists between serum cholesterol elevation and increase cases of high blood glucose (*3). A slight correlation exists between serum cholesterol elevation and glucose elevation that are determined from the same sample. While no correlation exists between the elevation of serum triglyceride value and serum glucose value that are determined from the same sample. Last, no forward or inverse relationship exists between serum triglyceride and serum glucose that are determined from the same sample. Same applies for the cholesterol, as no forward or inverse relationship exists between serum cholesterol and serum glucose that are determined from the same sample.

References:

1- Roman SH, Harris MI. Management of diabetes mellitus from a public health perspective. Endocrinol Metab Clin North Am 1997; 26:443-74.

2- Harris MI. Health care and health status and outcomes for patients with type 2 diabetes. Diabetes Care 2000; 23:754-8.

3- Esperanza R Briones, PhD, Dianne L Steiger, BS, PJ Palumbo, MD, et.al. Sterol excretion and cholesterol absorption in diabetics and nondiabetics with and without hyperlipidemia. The American Journal of Clinical Nutrition 44: SEPTEMBER 1986, pp 353-361.

4- TIMOTHY O'BRIEN, M.D., PH.D. TU T. NGUYEN, M.D. BRUCE R. ZIMMERMAN, . M.D. Hyperlipidemia and Diabetes Mellitus. Mayo Clin Proc 1998;73:969-976.

5- A ndrea Bonanoine. A driana Vison, Luigi Lusiani, et-al. Carbohydrate and lipid metabolism in patients with non-insulin-dependent diabetes mellitus:
effects of a low-fat, high-carbohydrate diet vs a diet high in monounsaturated fatty acids. Am J C/in Nuir 199 1:54:586-90.

6- VINCENT POITOUT AND R. PAUL ROBERTSON. Minireview: Secondary -Cell Failure in Type 2 Diabetes—A Convergence of Glucotoxicity and Lipotoxicity. Endocrinology, February 2002, 143(2):339–342

7- LEO E. HOLLISTER, M.D.,2 JOHN E. OVERALL, PH.D.,I AND HAROLD L. SNow, M.D.4 Relationship of Obesity to Serum Triglyceride, Cholesterol, and Uric Acid, and to Plasma-Glucose Levels' . The AMERICAN JOURNAL OF CLINICAL NUTRITION Vol. 20, No. 7, July, 1967, pp. 777-782 *.Printed in L.S.A.*

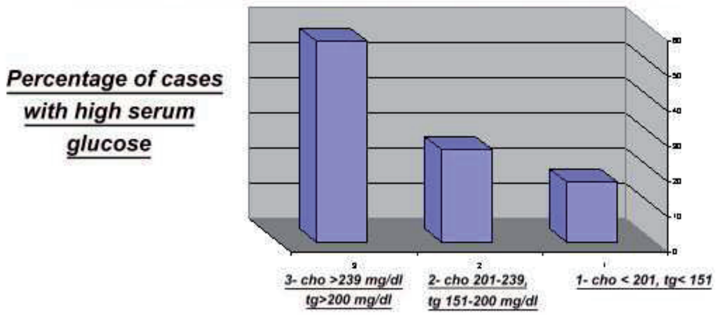
8- Hettihewa Lukshmy Menik, Jayasinghe Sudheera Sammanthi, Weerarathna Thilak Priyantha, et-al. Genetic Association Between Insulin Resistance And Total Cholesterol In Type 2 Diabetes Mellitus - A Preliminary Observation. *Online J Health Allied Scs.* 2005;1:4

9- S. C. MELUDU, _L. ASOMUGHA, E. C. DIOKA, et-al. EXERCISE PERFORMANCE IN RELATION TO GLUCOSE DRINK AND THEISOME BIOCHEMICAL PARAMETERS. Nigerian Journal of Physiological Sciences, Vol. 20, No. 1-2, 2005, pp. 43-47

10- Elias S.Siraja, et.al. Lipid and lipoprotein profiles in Ethiopian patients with diabetes mellitus. Metabolism clinical and experimental, Pages 706-710 (June 2006) .Issue 6.Volume 55.

11- Abdul Rahman Al-Nuaim. Effect of overweight and obesity on glucose intolerance and dyslipidemia in Saudi Arabia, epidemiological study. Diabetes research and clinical practice Journal Issue 3, Volume 36, Pages 181-191 (June 1997)

The association between serum cholesterol and triglyceride elevation and the elevated # ofcases with high serum glucose > 110 mg/dl



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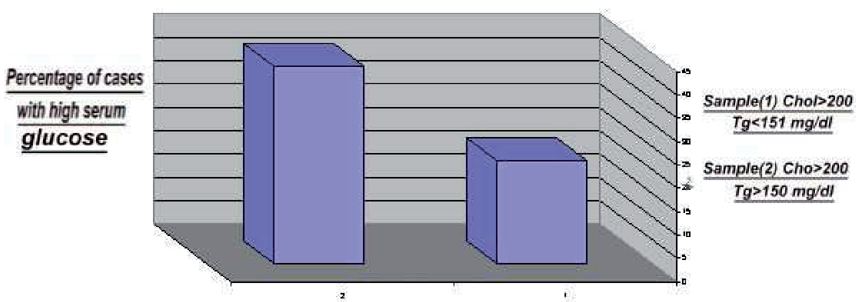
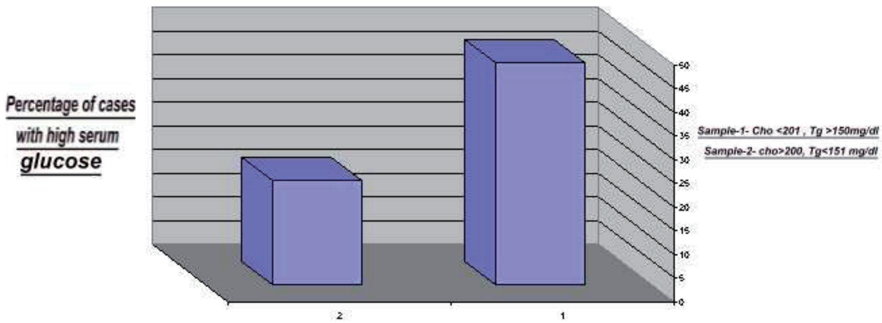
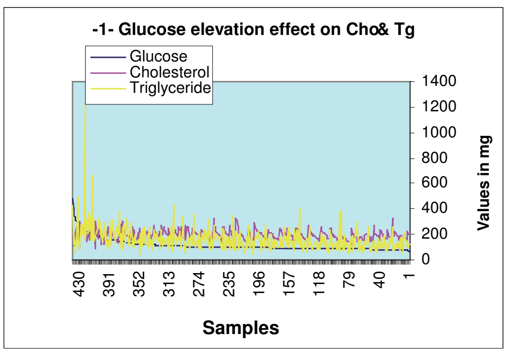
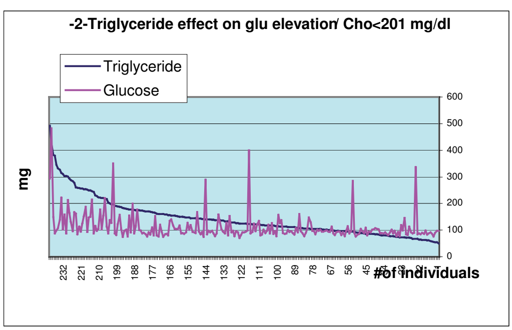
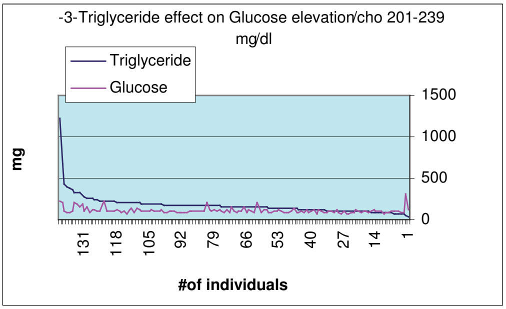


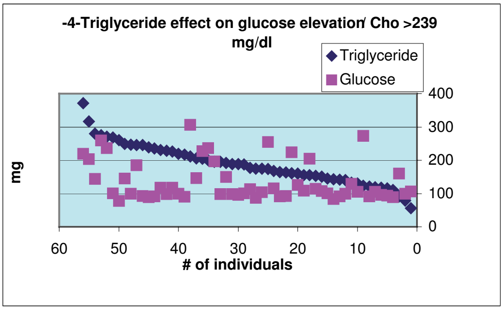
A comparison between the association of sample (1) and sample (2) with the increase cases of high glucose

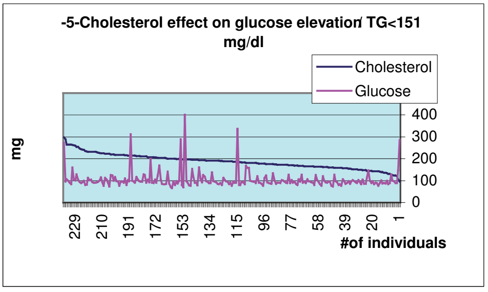


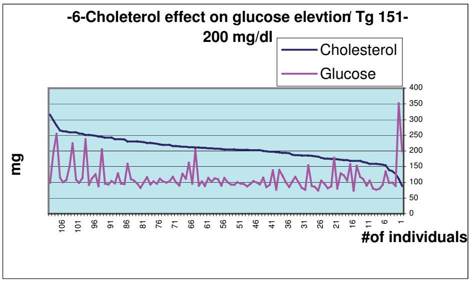


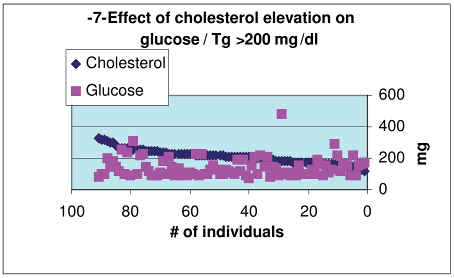


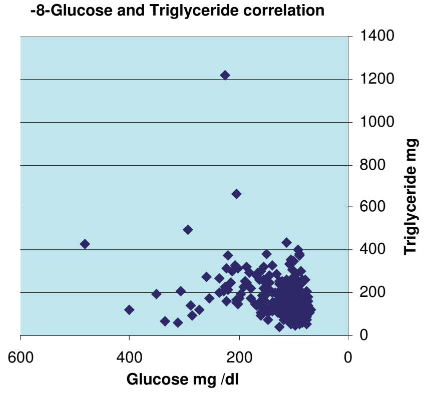

-3-Triglyceride effect on Glucose elevation/cho 201-239 mg/dl
Triglyceride
Glucose
mg
1500
1000
500
0
131
118
105
92
79
66
53
40
27
14
1
#of individuals

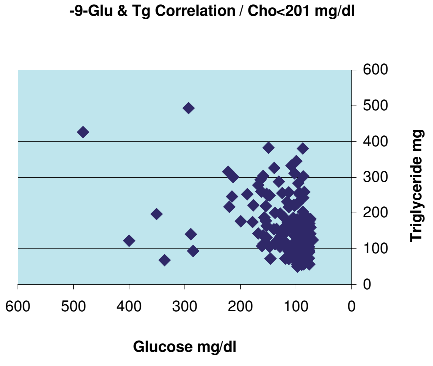

-4-Triglyceride effect on glucose elevation/ Cho >239 mg/dl
Triglyceride
Glucose
mg
400
300
200
100
0
60
50
40
30
20
10
0
# of individuals

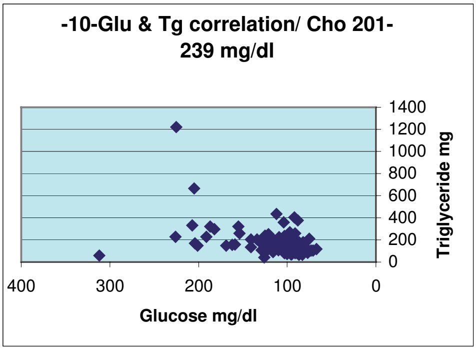

-5-Cholesterol effect on glucose elevation/ TG<151 mg/dl
Cholesterol
Glucose
mg
400
300
200
100
0
229
210
191
172
153
134
115
96
77
58
39
20
1
#of individuals

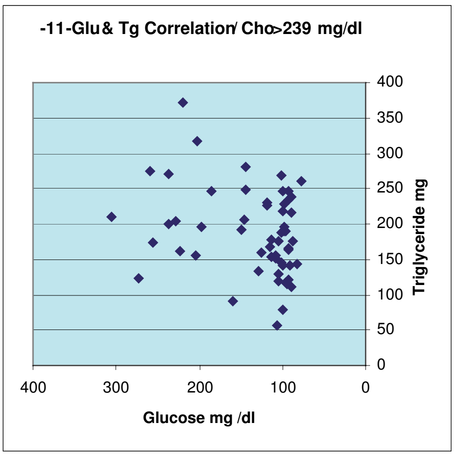

-6-Choleterol effect on glucose elevtion/ Tg 151-200 mg/dl
Cholesterol
Glucose
mg
400
350
300
250
200
150
100
50
0
106
101
96
91
86
81
76
71
66
61
56
51
46
41
36
31
26
21
16
11
6
1
#of individuals

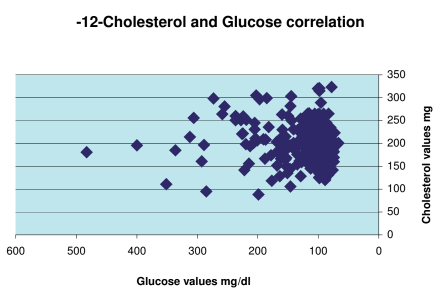

-7-Effect of cholesterol elevation on glucose / Tg >200 mg/dl
Cholesterol
Glucose
600
400
200
0
mg
100
80
60
40
20
0
# of individuals

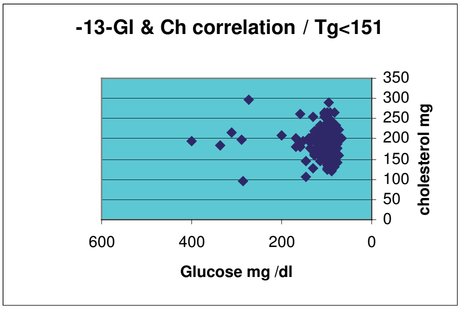

-8-Glucose and Triglyceride correlation
1400
1200
1000
800
600
400
200
0
Triglyceride mg
600
400
200
0
Glucose mg /dl

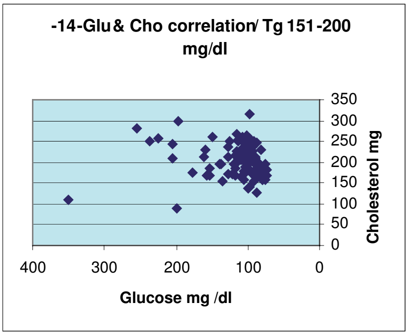

-9-Glu & Tg Correlation / Cho<201 mg/dl
600
500
400
300
200
100
0
Triglyceride mg
600
500
400
300
200
100
0
Glucose mg/dl

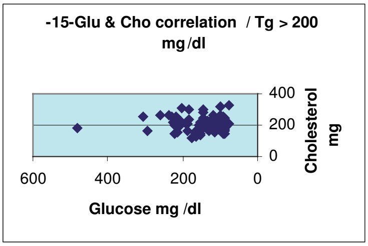

-10-Glu & Tg correlation/ Cho 201-239 mg/dl
1400
1200
1000
800
600
400
200
0
Triglyceride mg
400
300
200
100
0
Glucose mg/dl


-11-Glu & Tg Correlation/ Cho>239 mg/dl
400
350
300
250
200
150
100
50
0
Triglyceride mg
400
300
200
100
0
Glucose mg /dl


-12-Cholesterol and Glucose correlation
350
300
250
200
150
100
50
0
Cholesterol values mg
600
500
400
300
200
100
0
Glucose values mg/dl


-13-Gl & Ch correlation / Tg<151
350
300
250
200
150
100
50
0
cholesterol mg
600
400
200
0
Glucose mg /dl


-14-Glu & Cho correlation/ Tg 151-200 mg/dl
350
300
250
200
150
100
50
0
Cholesterol mg
400
300
200
100
0
Glucose mg /dl


-15-Glu & Cho correlation / Tg > 200 mg/dl
400
200
0
Cholesterol mg
600
400
200
0
Glucose mg /dl

A study measures the effect of high serum Cholesterol and Glucose on Triglyceride elevation in human serum

Objective: The aim of this study was to test the hypothesis of the presence of any correlation and if found, the regression nature of such correlation between glucose and triglyceride levels in one hand, and cholesterol and triglyceride levels in the other hand.

Research Methods and Procedures: The sample was gathered from 438 individuals of non-diabetic patients, and non-insulin dependent type-II- diabetic patients. Dividing the study group in to different categories according to the levels of both cholesterol and glucose, a comparison study was conducted on the association of the elevated level of each of the parameters (cholesterol and glucose) with triglyceride elevation.

Results: With cholesterol and glucose elevation together, the Chi-Square value was (11.25) beyond boundaries of rejection at 0.05 level of significance. While when comparing between cholesterol and glucose, the Chi-Square value remained under boundaries of rejection. With all the 438 individuals studied, the correlation coefficient values (0.206 for the glucose and 0.352 for the cholesterol) are relatively, positively correlated with triglyceride.

Conclusion: An association exists between serum glucose or cholesterol or both together elevation, and the increase cases of high blood triglyceride.

Introduction: Triglyceride is the main type of fat transported by human body. The fat gets its name from its chemical structure. Triglycerides are normal components in the bloodstream. After eating, the body digests the fats in the food and releases triglycerides into the blood stream. They are transported throughout the body to produce energy or to be stored as fat. The liver also produces triglycerides and changes some into cholesterol. The liver can change any source of excess calories into triglycerides.

Hypertriglyceridemia is associated with increased synthesis and decreased degradation of very low density lipoproteins (VLDL) and triglyceride.

Cholesterol synthesis and degradation is affected by VLDL and triglyceride metabolism(1). Blood hypercholesterolemia is associated with blood hypertriglyceridemia, which means that both cholesterol and triglyceride elevation are not independent of each other (2).

It is well known that the most common abnormality in diabetes mellitus is Hypertriglyceridemia. A diet rich in glucose as study (3) pointed out, caused a prolonged elevation in serum triglyceride for a long time. A significant elevation in blood glucose and serum triglyceride was noticed after 30-60-150 minutes of the glucose rich drink consumption and jogging (4) .

The studies on type II diabetes revealed that, those patients do have problems in lipids concentration and metabolism (5). In patients with type II diabetes mellitus a goal of low-density lipoprotein cholesterol of less than 200 mg/dL and triglycerides lower than 130 mg/dL should be sought (6).

TG and HDL-C are closely associated. In addition, in comparison with HDL-C, the distribution of TG levels is markedly skewed, requiring logarithmic transformation for distribution-dependent analyses such as standard regression analysis, a statistical maneuver that may not provide an appropriate representation of underlying biological processes (7).

This study was conducted to evaluate the interrelations documented in the previous studies and to test the hypothesis of the presence of any correlation and if found, the regression nature of such correlation between glucose and triglyceride levels in one hand and cholesterol and triglyceride levels in the other hand.

Materials and Methods:

Samples were collected from patients who came to the laboratory located in the center of Damascus city during the date between March and August 2009. The sample was gathered from two patient types, the first is non-diabetic patients who came for general laboratory checkup, and the second is non-insulin dependent type-2- diabetic patients. The sample consisted of 438 of both males and females in age between 38-86 years who had their blood drawn and fasting serum glucose; cholesterol and triglyceride were similtinuasly determined. Dividing the study group in to different categories according to the levels of both cholesterol and glucose, the study considered the normal cholesterol level up to 200 mg/dl and the normal level of glucose up to 110 mg/dl. Moderate high level of cholesterol was considered 201-250 mg/dl and of glucose it was 111-150 mg/dl. The levels of cholesterol > 250 and of glucose > 150 were considered as very high levels.

A comparison study was conducted on the effect of the elevated level of each of the parameters (cholesterol and glucose) on triglyceride elevation as follows:

Study-1- measures the number of cases of high serum triglyceride > 150 mg/dl in the three different serum cholesterol and glucose groups: 1- (glucose <111 mg/dl, cholesterol<201 mg/dl), 2- (glucose 111-150 mg/dl, cholesterol 201-250 mg/dl), 3-(glucose >150 mg/dl, cholesterol>250 mg/dl).

Study-2- measures the number of cases of high serum triglyceride > 150 mg/dl in the two different serum cholesterol and glucose groups: 1-(glucose <111 mg/dl, cholesterol>200 mg/dl), 2- (glucose >110 mg/dl, cholesterol>200 mg/dl).

Study-3- measures the number of cases of high serum triglyceride > 150 mg/dl in the two different serum cholesterol and glucose groups 1-(glucose >110 mg/dl, cholesterol<201 mg/dl), 2- (glucose >110 mg/dl, cholesterol>200 mg/dl).

Study-4- measures the number of cases of high serum triglyceride > 150 mg/dl in the two different serum cholesterol and glucose groups 1-(glucose

<111 mg/dl, cholesterol>200 mg/dl), 2- (glucose >110 mg/dl, cholesterol<201 mg/dl).

Study-5- measures the triglyceride mean and standard deviation under the following categories: 1- Individuals with normal glucose normal cholesterol. 2- High glucose normal cholesterol. 3-Normal glucose high cholesterol. 4- High glucose high cholesterol.

Study-6- measures both the correlation and the regression considering the glucose as the independent variable and the triglyceride as the dependant one.

Study-7- measures both the correlation and the regression considering the cholesterol as the independent variable and the triglyceride as the dependant one.

Study-8- measures under normal glucose levels both the correlation and the regression considering the cholesterol as the independent variable and the triglyceride as the dependant one.

Analysis and results:

Table-1- Measuring the number of cases of high serum triglyceride>150 mg/dl among groups: 1-(cholesterol < 201 mg/dl, glucose <111 mg/dl), and 2- (cholesterol 201-250 mg/dl, glucose 111-150 mg/dl). 3- cholesterol >250 mg/dl, glucose >150 mg/dl

Glucose Cholesterol mg /dl	Total number of cases studied	Number of High triglyceride cases >150 mg/dl	Expected # of cases with tg >150 mg/dl	Chi-Square value

Glucose<111 Cho<201	176	43	55.5	11.25
Glucose 111-150 Cho 201-250	32	21	13.43	
Glu>150 Cho>250	13	11	6.08	

Table-2- Measuring the number of cases of high serum triglyceride > 150 mg/dl between groups: 1-(cholesterol <201 mg/dl, glucose>110 mg/dl), and 2- (cholesterol >200 mg/dl, glucose>110 mg/dl).

Glucose Cholesterol mg /dl	Total number of cases studied	Number of High triglyceride cases >150 mg/dl	Expected # of cases with tg>150mg/dl	Chi-Square value
glu>110 Cho<201	65	37	40.62	0.6
glu>110 Cho>200	68	51	47.38	

Table-3- Measuring the number of cases of high serum triglyceride > 150 mg/dl between groups: 1-(cholesterol >200 mg/dl, glucose< 111 mg/dl), 2- (cholesterol >200 mg/dl, glucose > 110 mg/dl).

Glucose	Total number of	Number of	Expected # of	Chi-Square

Cholesterol mg /dl	cases studied	High cholesterol cases >200 mg/dl	cases with cholesterol >200 mg/dl	value
glu<111 cho>200	129	69	74.95	1.26
Glu >110 Cho>200	68	51	45.04	

Table-4- Measuring the number of cases of high serum triglyceride >150 mg/dl between groups: 1-(cholesterol >200 mg/dl, glucose < 111 mg/dl), 2-(cholesterol <201 mg/dl, glucose> 110 mg/dl)

Glucose Triglyceride mg /dl	Total number of cases studied	Number of High cholesterol cases >200 mg/dl	Expected # of cases with cholesterol >200 mg/dl	Chi-Square value
glu<111 Ch>200	129	69	69.96	0.04
Glu >110 Cho<201	65	37	36.04	

Table (5): Measuring the triglyceride mean and standard deviation under the following categories: 1- Normal cholesterol normal glucose. 2- High cholesterol normal glucose . 3-Normal cholesterol high glucose. 4- High cholesterol high glucose.

Triglyceride	Normal cholesterol<201mg/dl Normal glucose <111 mg/dl	High cholesterol>200 mg/dl normal glucose<111 mg/dl	Normal cholesterol high glucose	High cholesterol high glucose
# of patients	176	129	65	68
Average	127.5	158.71	188.046	215.044
STD	56.81	60.20	87.34	153.99

Table (6) Measuring both the correlation and the regression considering the glucose as the independent variable and the triglyceride as the dependant one.

	All the 438 individuals	: Glucose is normal <111 mg/dl	: Glucose is 111-150 mg/dl	: Glucose is >150mg/dl
(r) (the correlation coefficient)	0.352	0.083	0.168	0.049
Regression P (slope)	0.660	0.564	1.053	0.122
S *y.x* (Standard error of estimate)	84.43	56.77	68.27	167.31
S*b* (Estimated	0.084	0.512	0.73	0.333

standard error value				
TR (The test ratio)	7.85	1.1	1.44	0.365
At 95% confidence interval B=	5.9<B<9.81	0	0	0

Table (7) Measuring both the correlation and the regression considering the cholesterol as the independent variable and the triglyceride as the dependant one.

	All the 438 individuals	: Cholesterol is normal<201 mg/dl	: Cholesterol is 201-250 mg/dl	: Cholesterol is >250 mg/dl
(r) (the correlation coefficient	0.206	0.061	0.0897	0.28
Regression P (slope)	0.487	0.207	0.787	0.794
S *y.x* (Standard error of estimate)	88.28	71.51	114.01	61.15
S*b* (Estimated standard	0.11	0.217	0.7	044

error value				
TR (The test ratio)	4.41	0.953	1.12	1.8
At 95% confidence interval B=	8.4<B<12.32	0	0	0

Table (8) Measuring both the correlation and the regression considering the cholesterol as the independent variable and the triglyceride as the dependant one, With normal glucose levels < 111mg/dl

	All the 438 individuals	: Cholesterol is normal<201 mg/dl/ normal glu	: Cholesterol is -201-250 mg/dl normal glu	: Cholesterol is >250 mg/dl normal glu
(r) (the correlation coefficient	0.206	0.163	0.160	0.499
Regression P (slope)	0.487	0.481	0.760	1.09
S *y.x* (Standard error of estimate)	88.28	56.2	60.48	48.54
S*b* (Estimated standard	0.11	0.22	0.45	0.446

error value				
TR (The test ratio)	4.41	2.186	1.68	2.44
At 95% confidence interval B=	8.4<B<12.32	- 0.226<B<4.14	0	-0.354<B<4.5

In the first four tables we used the Chi-Square test as a mean of comparing the results according to the following null hypotheses: The total number of elevated cases of triglyceride values > 150 mg/dl in the different study groups is equal under 0.05 level of significance. Thus there is no significant difference in elevated triglyceride level among the different study groups in such case.

The alternative hypotheses: The total number of elevated cases of triglyceride values > 110 mg/dl in the different study groups is not equal under 0.05 level of significance. Thus there is a significant difference in elevated triglyceride level among the different study groups in such case.

We have chosen in our study to reveal the influence of both elevated serum glucose and cholesterol levels on triglyceride level in blood on a step by step basis. Starting in table-1- by checking the effect of elevation in both glucose and cholesterol together on triglyceride, then moving a step forward in table-2- by checking the effect of glucose elevation while cholesterol is normal and comparing that with the effect of both high cholesterol and glucose. In table-3- we checked-in the effect of cholesterol elevation while glucose is normal and compared that with the effect of both high cholesterol and glucose. We decided in table-4- to compare the effect of high glucose normal cholesterol with the effect of high cholesterol normal glucose cases on the number of cases of high triglyceride in serum .

Table (1) indicates that 43/176 individuals in group –1- with their glucose<111 mg/dl and cholesterol<201 mg/dl having high triglyceride levels. While with their glucose 111-150 mg/dl and cholesterol 201-250 mg/dl, 21/32 individuals in group –2- having high triglyceride levels. And with their glucose >150 mg/dl and cholesterol>250 mg/dl, 11/13 individuals in group –3 having high triglyceride levels. The Chi-Square value is 11.25> 5.99 under the 0.05 level of significance, and there is a significant difference in the number of cases with high triglyceride values > 150 mg/dl among the three different study groups.

Table (2) indicates that 37/65 individuals in group –1- with their glucose>110 mg/dl and cholesterol<201 mg/dl having high triglyceride levels. While with their glucose >110mg/dl and cholesterol>200 mg/dl, 51/68 individuals in group –2- having high triglyceride levels. The Chi-Square value is 0.6< 3.88 under the 0.05 level of significance, and there is no significant difference in the number of cases with high triglyceride values > 150 mg/dl between the two different study groups.

Table (3) indicates that 69/129 individuals in group –1- with their glucose<111 mg/dl and cholesterol>200 mg/dl having high triglyceride levels. While with their glucose >110mg/dl and cholesterol>200 mg/dl, 51/68 individuals in group –2- having high triglyceride levels. The Chi-Square value is 1.266>< 3.88 under the 0.05 level of significance, and there is no significant difference in the number of cases with high triglyceride values > 150 mg/dl between the two different study groups.

Table (4) indicates that 69/129 individuals in group –1- with their glucose<111 mg/dl and cholesterol>200 mg/dl having high triglyceride levels. While with their glucose >110mg/dl and cholesterol<201 mg/dl, 37/65 individuals in group –2- having high triglyceride levels. The Chi-Square value is 0.044< 3.88 under the 0.05 level of significance, and there is no significant difference in the number of cases with high triglyceride values > 150 mg/dl between the two different study groups.

In table (5) we checked the mean and standard deviation. The study found that in the 160 individuals having normal glucose <111 mg/dl and normal cholesterol <201 mg/d, the average triglyceride value was 127.5 mg/dl and the standard deviation was 56.81. While in the 65 Individuals having high glucose >110 mg/dl and normal cholesterol <201 mg/dl, the average triglyceride value was 188.04 mg/dl and the standard deviation was 87.34. And in the 129 individuals having normal glucose < 111 mg/dl and high cholesterol >201 mg/dl, the average triglyceride value was 158.7 mg/dl and the standard deviation was 60.20. And in the 120 individuals having high glucose > 110 mg/dl and high cholesterol >201 mg/dl, the average triglyceride value was 215.044 mg/dl and the standard deviation was 153.99.

Further, the study in table (6) checked the presence of any correlation and hence, the regression considering the glucose as the independent variable and the triglyceride as the dependant one. The correlation coefficient value was 0.352 for all the 438 individuals that the study was conducted on. While with individuals having normal glucose <111mg/dl, the correlation coefficient value was 0.083. And with the group with glucose value 111-150 mg/dl, the correlation coefficient value was 0.168. And with the group with glucose value>150 mg/dl, the correlation coefficient value was 0.049. Likewise, the study in table (7) checked the presence of any correlation and hence, the regression considering the cholesterol as the independent variable and the triglyceride as the dependant one. The correlation coefficient value was 0.206 for all the 438 individuals that the study was conducted on. While with individuals having normal cholesterol <201mg/dl, the correlation coefficient value was 0.061 and with the group with cholesterol value 201-250 mg/dl, the correlation coefficient value was also 0.089 and with cholesterol value >250 mg/dl, the correlation coefficient value was 0.283.

In both tables 6 and 7, the t test studied the regression slope at 5% level of significance under the assumption that the slope of the samples according to the different categories presented above is zero. In the glucose case, the test ratio for the t test for the slope (TR) in all the 438 individuals was 7.85. Thus a true forward relationship exists between the elevation in serum glucose and the elevation in serum triglyceride in every single sample when test is done on the same sample from the same patient. When applying the same test under the other different glucose categories (TR) was < 1.96, which is very small to reject our assumption. Thus in those 3 categorized cases, glucose <111mg/dl, glucose value 111-150 mg/dl, glucose value>150 mg/dl, we accept our hypotheses that no true relationship exists between the elevation in serum glucose and the elevation in serum triglyceride in the same sample according to table (6). In other words, in each and every single sample, elevation in glucose does not necessarily, in the same manner, associate with the same level of triglyceride elevation when test is done on the same sample from the same patient. Likewise, , what applies to table(6) appears exactly the same in table (7).The test ratio for the t test for the slope (TR) in all the 438 individuals was 4.41. Thus a true forward relationship exists between the elevation in serum cholesterol and the elevation in serum triglyceride in every single sample when test is done on the same sample from the same patient. While on applying the same test under the other 3 different cholesterol categories, (TR) was < 1.96, which is small enough to reject our assumption. Thus in those 3 cholesterol categorized cases, we accept our hypotheses that no true forward or reverse relationship exists between the elevation in serum cholesterol and the elevation in serum triglyceride in every single sample when test is done on the same sample from the same patient. That means, high level of cholesterol does not have to be associated with the same high triglyceride level in the same sample.

The study again was forwarded an other step by checking in table (8) the regression slope at 5% level of significance considering the cholesterol as the independent variable and the triglyceride as the dependant one for non diabetic individuals who had normal glucose levels < 111mg/dl under the following categories: 1- All the 438 individuals, 2- Cholesterol is normal<201 mg/dl/, 3- Cholesterol is -201-250 mg/dl, 4- Cholesterol is >250 mg/dl .The correlation was 0.206, 0.163, 0.160, 0.499 respectively. The test ratio for the t test for the slope (TR) in all the categories except one (where the Cholesterol is -201-250 mg/dl) was >2. Thus in those categories, a true forward relationship exists between the elevation in serum cholesterol and the elevation in serum triglyceride in every single sample when test is done on the same sample from the same patient.

Discussion:

This retrospective study aims at further identifying the real effect of the elevation of serum glucose and serum cholesterol separately or in combination, on triglyceride levels in blood. The results in table (1) reveals that the elevation in both glucose and cholesterol similtinuasly has an association with increasing cases of elevated triglyceride in blood and thus may have an effect on elevated blood triglyceride. Table (2) declares the absence of any significant difference and hence, in diabetic patients the elevation in cholesterol has no further impact on increasing cases of high triglyceride in blood. The results in table (3) show no significant difference between the cholesterol elevation alone and the elevation in both glucose and cholesterol. Thus we conclude that in hypercholesterolemic individuals, glucose elevation has no further impact on increasing cases of high triglyceride in blood. That last statement is confirmed by the results in table (4) where it shows an absence of any significant difference between the effect of glucose elevation compared to the cholesterol elevation on the association with the number of cases with high triglyceride levels in blood. So glucose or cholesterol elevation or both, seem to have an impact on increasing the number of cases with high blood triglyceride. To confirm our findings we tested in table (5) the average of serum triglyceride values under the four categories: normal glucose and cholesterol, normal glucose high cholesterol, high glucose normal cholesterol, high glucose high cholesterol. It is clear from the results presented that the average triglyceride value is increasing with the elevation in glucose alone or the cholesterol alone and it shows higher increase with both together elevation.

In tables (6-7) we tested the correlation and regression values. It is obvious that overall, with the whole number of 438 individuals tested, both cholesterol and glucose are relatively, positively correlated with triglyceride as we see from the correlation coefficient values. They varied between 0.352 for the glucose and 0.206 for the cholesterol. The correlation coefficient values became negligible in the different glucose categories, (Glucose is normal <111 mg/dl, Glucose is 111-150 mg/dl, Glucose is >150mg/dl) or the different cholesterol categories (Cholesterol is normal<201 mg/dl, Cholesterol is 201-250 mg/dl, Cholesterol is >250 mg/dl) .

When testing the hypothesis of a real forward or inverse relationship existence between glucose and triglyceride or between cholesterol and triglyceride as for example, when a glucose or cholesterol value goes up or down, the corresponding triglyceride value goes in the same direction, we found that the TR value (the test ratio for the t test for slope) for the 438 individuals tested for the cholesterol and the glucose were 4.41 and 7.85 respectively. We conclude that there is a forward relationship exists between serum glucose or serum cholesterol and serum triglyceride as a value to value, in the same sample. That was not the case when we divided our data consisting of the 438 individuals into the presented above categories. As it is shown from both tables 6 and 7, that all values were less than 1.96. In both cases the values are far bellow the boundaries of the rejection region so we accept our hypothesis: (the value of B which is the slope of each tested sample regression line is (0) and thus, no forward or inverse relationship exists between serum glucose and serum triglyceride as a value to value, in the same sample or between serum cholesterol and serum triglyceride as a value to value, in the same sample under those different categories.

Last, when we tested the correlation between cholesterol and triglyceride in the case of non diabetic individuals as appears in table 8. The results shifted towards a real correlation and forward relationship between the cholesterol elevation and the triglyceride elevation.

In conclusion: A strong association exists between both serum glucose and cholesterol elevation together, and the increase cases of high blood triglyceride. An association exists between serum glucose elevation and the increase cases of high blood triglyceride. An association exists between serum cholesterol elevation and increase cases of high blood triglyceride .A slight correlation exists between serum triglyceride elevation and cholesterol elevation that are determined from the same sample. A slight correlation exists between serum triglyceride elevation and glucose elevation that are determined from the same sample. Last, from the data consisted of all the 438 individuals, there is a forward relationship exists between serum glucose level and serum triglyceride level that are determined from the same sample. Same applies for the cholesterol, as there is a forward relationship exists between serum cholesterol level and serum triglyceride level that are determined from the same sample.

References:

1-Esperanza R Briones, PhD, Dianne L Steiger, BS, PJ Palumbo, MD, et.al. Sterol excretion and cholesterol absorption in diabetics and nondiabetics with and without hyperlipidemia. The American Journal of Clinical Nutrition 44: SEPTEMBER 1986, pp 353-361.

2- LEO E. HOLLISTER, M.D.,2 JOHN E. OVERALL, PH.D.,I AND HAROLD L. SNow, M.D.4 Relationship of Obesity to Serum Triglyceride, Cholesterol, and Uric Acid, and to Plasma-Glucose Levels' . The AMERICAN JOURNAL OF CLINICAL NUTRITION Vol. 20, No. 7, July, 1967, pp. 777-782 *.Printed in L.S.*

3-Kannel WB, Gordon T, Castelli WP. Obesity, Lipids and glucose intolerance: the Framigham Study. Am J Clin Nutr 1979;32:1238-45.

4- S. C. MELUDU, _L. ASOMUGHA, E. C. DIOKA, et-al. EXERCISE PERFORMANCE IN RELATION TO GLUCOSE DRINK AND THEISOME BIOCHEMICAL PARAMETERS. Nigerian Journal of Physiological Sciences, Vol. 20, No. 1-2, 2005, pp. 43-47

5-_A ndrea Bonanoine. A driana Vison, Luigi Lusiani, et-al. Carbohydrate and lipid metabolism in patients with non-insulin-dependent diabetes mellitus:
effects of a low-fat, high-carbohydrate diet vs a diet high in monounsaturated fatty acids. Am J C/in Nuir 199 1:54:586-90.

6- T. O. Brien, T. T. Nguyen and B. R. Zimmerman. Hyperlipidemia and diabetes mellitus. *doi:* 10.4065/ 73.10.969 Mayo Clinic Proceedings October 1998 vol. 73 no. 10 969-976

7- J ørgen Jeppesen, MD; Hans Ole Hein, MD; Poul Suadicani, DD; ; Finn Gyntelberg, MD.

8- Triglyceride Concentration and Ischemic Heart Disease An Eight-Year Follow-up in the Copenhagen Male Study. (*Circulation.* 1998;97:1029-1036.) © 1998 American Heart Association, Inc.

A study measures the effect of high serum Triglyceride and Glucose on Cholesterol elevation in human serum

Objective: The aim of this study was to test the hypothesis of the presence of any correlation and if found, the regression nature of such correlation between glucose and cholesterol levels in one hand, and triglyceride and cholesterol levels in the other hand.

Research Methods and Procedures: The sample was gathered from 438 individuals of non-diabetic patients, and non-insulin dependent type-II- diabetic patients. Dividing the study group in to different categories according to the levels of both triglyceride and glucose, a comparison study was conducted on the association of the elevated level of each of the parameters (triglyceride and glucose) with cholesterol elevation.

Results: The Chi-Square value among the different study groups was always under boundaries of rejection at 0.05 level of significance.

Conclusion: No association exists between serum glucose or triglyceride or both together elevation, and the increase cases of high blood cholesterol

Introduction: It is well known that the most common abnormality in diabetes mellitus is hypertriglyceridemia.[1] Hypertriglyceridemia is associated with increased synthesis and decreased degradation of very low density lipoproteins (VLDL) and triglyceride. Cholesterol synthesis and degradation is affected by VLDL and triglyceride metabolism.[2] High density lipoprotein level(HDL) is decreased in patients with diabetes. Diabetes has a known effect on cholesterol metabolism. This effect is independent of the associated Hyperlipidemia.[3] Prevention of diabetes complications is achieved by controlling among other factors serum lipids. 58% of the Americans who participated in diabetes survey had poor lipid control.[4] Clinical inertia is defined as the recognition of the problem, but failure to act.[5] In the united states, a diagnosis is only made for 47% of patients with elevated cholesterol levels.[6] Pharmacologic therapy is used for approximately 17% to 23% of those with elevated cholesterol levels.[7] In patients with type II diabetes mellitus a goal of low-density lipoprotein cholesterol of less than 130 mg/dL and triglycerides lower than 200 mg/dL should be sought.[8] In a study titeled : "Lipid and lipoprotein profiles in Ethiopian patients with diabetes mellitus"[9], hypercholesterolemia and hypertriglyceridemia were found in 47.3% and 41.8% of patients with diabetes mellitus compared with 27% and 17% in normal controls ($P<.05$ for both). The mean total cholesterol level+/-SEM was significantly higher in patients with type 1 or II diabetes mellitus than normal controls. Triglycerides and low-density lipoprotein levels were also significantly higher in patients with diabetes than in controls, whereas high-density lipoprotein levels were significantly lower in patients with diabetes.

These complex interrelations among hypertriglyceridemia, type II diabetes mellitus in one hand and hypercholesterolemia and dyslipidemia in the other hand may suggest that elevation in serum triglyceride or glucose in human body may have an effect or association with serum cholesterol elevation.

This study was conducted to evaluate the relationship between serum triglyceride and glucose elevation, effecting serum cholesterol levels in human blood as was documented in the previous studies, and to test the hypothesis of the presence of any correlation and if found, the regression nature of such correlation between glucose and cholesterol levels in one hand, and triglyceride and cholesterol levels in the other hand.

Materials and Methods:

Samples were collected from patients who came to the laboratory located in the center of Damascus city during the date between March and August 2009. The sample was gathered from two patient types, the first is non-diabetic patients who came for general laboratory checkup, and the second is non-insulin dependent type-II- diabetic patients. The sample consisted of 438 of both males and females in age between 38-86 years who had their blood drawn and fasting serum glucose; cholesterol and triglyceride were similtinuasly determined. Dividing the study group in to different categories according to the levels of both triglyceride and glucose, the study considered the normal triglyceride level up to 150 mg/dl and the normal level of glucose up to 110 mg/dl. Moderate high level of triglyceride was considered 151-200 mg/dl and of glucose it was 111-150 mg/dl. The level of triglyceride > 200 and of glucose > 150 were considered as very high levels.

A comparison study was conducted on the effect of the elevated level of each of the parameters (triglyceride and glucose) on cholesterol elevation as follows:

Study-1- measures the number of cases of high serum cholesterol >200 mg/dl in the three different serum triglyceride and glucose groups: 1- normal levels (glucose <111 mg/dl, triglyceride <151mg/dl), 2- moderate high levels (glucose 111-150 mg/dl, triglyceride 151-200 mg/dl), 3- high levels (glucose >150 mg/dl, triglyceride >200 mg/dl).

Study-2- measures the number of cases of high serum cholesterol > 200 mg/dl in the two different serum triglyceride and glucose groups: 1- diabetic individuals with normal triglyceride (glucose >110 mg/dl, triglyceride <151mg/dl) versus, 2- diabetic patients with high level of triglyceride (glucose >110 mg/dl, triglyceride >150 mg/dl).

Study-3- measures the number of cases of high serum cholesterol > 200 mg/dl in the two different serum triglyceride and glucose groups 1-non diabetic individuals with high level of triglyceride (glucose <111 mg/dl, triglyceride >150 mg/dl) versus, 2- diabetic patients with high level of triglyceride (glucose >110 mg/dl, triglyceride >150 mg/dl).

Study-4- measures the number of cases of high serum cholesterol > 200 mg/dl in the two different serum triglyceride and glucose groups: 1- non diabetic individuals with high level of triglyceride (glucose <111 mg/dl, triglyceride >150 mg/dl) versus, 2- diabetic individuals with normal triglyceride (glucose >110 mg/dl, triglyceride <151 mg/dl).

Study-5- measures the cholesterol mean and standard deviation under the following categories: 1- Individuals with normal glucose normal triglyceride. 2- Normal glucose high triglyceride. 3- High glucose normal triglyceride . 4- High glucose high triglyceride.

Study-6- measures both the correlation and the regression considering the glucose as the independent variable and the cholesterol as the dependant one.

Study-7- measures both the correlation and the regression considering the triglyceride as the independent variable and the cholesterol as the dependant one.

Study-8- measures both the correlation and the regression considering the triglyceride as the independent variable and the cholesterol as the dependant one with normal glucose value.

Analysis and results:

Table-1- Measuring the number of cases of high serum cholesterol > 200 mg/dl among groups: 1-(triglyceride <151 mg/dl, glucose<111 mg/dl), and

2- (triglyceride 151-200 mg/dl, glucose 111-150 mg/dl). 3- triglyceride >200 mg/dl, glucose >150 mg/dl

Glucose Triglyceride mg /dl	Total number of cases studied	Number of High cholesterol cases >200 mg/dl	Expected # of cases with cho >200 mg/dl	Chi-Square value
Glucose<111 Tg<151	193	60	67.5	3.5
Glucose 111-150 Tg 151-200	23	14	9.88	
Glu>150 Tg>200	31	16	12.55	

Table-2-Measuring the number of cases of high serum cholesterol > 200 mg/dl between groups: 1-(triglyceride <151 mg/dl, glucose>110 mg/dl), and 2- (triglyceride >150 mg/dl, glucose>110 mg/dl).

Glucose Triglyceride mg /dl	Total number of cases studied	Number of High cholesterol cases >200 mg/dl	Expected # of cases with cholesterol >200 mg/dl	Chi-Square value
glu>110 Tg<151	44	17	21.53	1.31

glu>110 Tg >150	99	61	56.47	

Table-3-Measuring the number of cases of high serum cholesterol > 200 mg/dl between groups: 1-(triglyceride >150 mg/dl, glucose< 111 mg/dl), 2- (triglyceride >150 mg/dl, glucose > 110 mg/dl).

Glucose Triglyceride mg /dl	Total number of cases studied	Number of High cholesterol cases >200 mg/dl	Expected # of cases with cholesterol >200 mg/dl	Chi-Square value
glu<111 Tg>150	112	69	69	0
Glu >110 Tg >150	99	61	61	

Table-4-Measuring the number of cases of high serum cholesterol>200 mg/dl between groups: 1-(triglyceride <151 mg/dl, glucose > 110 mg/dl), 2- (triglyceride >150 mg/dl, glucose< 111 mg/dl)

Glucose Triglyceride mg /dl	Total number of cases studied	Number of High cholesterol cases >200 mg/dl	Expected # of cases with cholesterol >200 mg/dl	Chi-Square value
glu<111 Tg>150	112	69	64.32	1.35

Glu >110 Tg <151	44	17	21.68	

Table (5): Measuring the cholesterol mean and standard deviation under the following categories: 1- Normal triglyceride normal glucose. 2- High triglyceride normal glucose . 3-Normal triglyceride high glucose. 4- High triglyceride high glucose.

Glucose	Normal triglyceride <151 mg/dl Normal glucose <111 mg/dl	High triglyceride >150 mg/dl normal glucose<111 mg/dl	Normal triglyceride high glucose	High triglyceride high glucose
# of patients	193	112	119	89
Average	186.33	208.56	191.72	207.29
STD	32.41	37.18	36.93	44.79

Table (6) Measuring both the correlation and the regression considering the glucose as the independent variable and the cholesterol as the dependant one.

	All the 438 individuals	: Glucose is normal <111 mg/dl	: Glucose is 111-150 mg/dl	: Glucose is >150mg/dl
(r) (the correlation	0.095	0.200	-0.0058	0.050

coefficient)				
Regression P (slope)	0.075	0.829	-0.01909	0.0383
S *y.x* (Standard error of estimate)	38.08	35.16	36.32	50.78
S*b* (Estimated standard error value	0.038	0.233	0.389	0.1
TR (The test ratio)	1.98	3.55	0.49	0.38
At 95% confidence interval B=	0.02<B<3.94	-1.13 to 2.79	0	0

Table (7) Measuring both the correlation and the regression considering the triglyceride as the independent variable and the cholesterol as the dependant one.

	All the 438 individuals	: Triglyceride is normal<151 mg/dl	: Triglyceride is 151-200 mg/dl	: Triglyceride is >200 mg/dl
(r) (the correlation coefficient	0.206	0.234	0.030	-0.03865

Regression P (slope)	0.487	0.298	0.082	-0.014
S *y.x* (Standard error of estimate)	88.28	32.42	37.28	44.799
S*b* (Estimated standard error value	0.047	0.081	0.26	0.0384
TR (The test ratio)	10.36	3.68	0.317	0.36
At 95% confidence interval B=	8.4<B<12.32	1.66<B<5.25	0	0

Table (8) Measuring both the correlation and the regression considering the triglyceride as the independent variable and the cholesterol as the dependant one. With normal glucose

	All the 438 individuals	: Triglyceride is normal<151 mg/dl/ normal glu	: Triglyceride is 151-200 mg/dl normal glu	: Triglyceride is >200 mg/dl normal glu
(r) (the correlation coefficient	0.206	0.250	0.11	-0.165

Regression P (slope)	0.487	0.314	0.29	-0.1319
S *y.x* (Standard error of estimate)	88.28	31.47	33.4	42.767
S*b* (Estimated standard error value	0.047	0.088	0311	0.129
TR (The test ratio)	10.36	3.56	0.93	1.022
At 95% confidence interval B=	8.4<B<12.32	1.6<B<5.52	0	0

In the first four tables we used the Chi-Square test as a mean of comparing the results according to the following null hypotheses: The total number of elevated cases of cholesterol values > 200 mg/dl in the different study groups is equal under 0.05 level of significance. Thus there is no significant difference in elevated cholesterol levels among the different study groups in such case.

The alternative hypotheses: The total number of elevated cases of cholesterol values > 200 mg/dl in the different study groups is not equal under 0.05 level of significance. Thus there is a significant difference in elevated cholesterol level among the different study groups in such case.

We have chosen in our study to reveal the influence of both elevated serum glucose and triglyceride levels on cholesterol level in blood on a step by step basis starting in table-1- by checking the effect of elevation in both glucose and triglyceride together on cholesterol, then moving a step forward in table-2- by checking the effect of glucose elevation while triglyceride is normal and comparing that with the effect of both high triglyceride and glucose. In table-3- we checked-in the effect of triglyceride elevation while glucose is normal and compared that with the effect of both high triglyceride and glucose. We decided in table-4- to compare the effect of high glucose normal triglyceride with the effect of high triglyceride normal glucose cases on the count of the number of cases of high cholesterol.

Table (1) indicates that 60/193 individuals in group –1- with normal levels, (glucose<111 mg/dl and triglyceride <151 mg/dl) are hypercholesterolemic. While with moderate high levels (glucose 111-150 mg/dl and triglyceride 151-200 mg/dl), 14/23 individuals in group –2- are hypercholesterolemic. And with high levels (glucose >150 mg/dl and triglyceride>200 mg/dl), 16/31 individuals in group –3- are hypercholesterolemic. The Chi-Square value is 3.5< 5.99 under the 0.05 level of significance, thus there is no significant difference in the number of cases with high cholesterol values > 200 mg/dl among the three different study groups.

Table (2) indicates that 17/44 individuals in group –1- diabetic individuals with normal triglyceride (glucose>110 mg/dl and triglyceride <151 mg/dl) are hypercholesterolemic. While in group –2- diabetic individuals with high triglyceride (glucose >110mg/dl and triglyceride >150 mg/dl), 61/99 individuals are hypercholesterolemic. The Chi-Square value is 1.31< 3.88 under the 0.05 level of significance, and there is no significant difference in the number of cases with high cholesterol values > 200 mg/dl between the two different study groups.

Table (3) indicates that 69/112 individuals in group –1- non diabetic individuals with high level of triglyceride (glucose<111 mg/dl and triglyceride>150 mg/dl) are hypercholesterolemic. While in group –2- diabetic patients with high level of triglyceride (glucose >110mg/dl and triglyceride>150 mg/dl), 61/99 individuals are hypercholesterolemic. The Chi-Square value is 0< 3.88 under the 0.05 level of significance, and there is no significant difference in the number of cases with high cholesterol values > 200 mg/dl between the two different study groups.

Table (4) indicates that 69/112 individuals in group –1- non diabetic individuals with high level of triglyceride (glucose<111 mg/dl and triglyceride>150 mg/dl) are hypercholesterolemic. While in group –2 diabetic individuals with normal triglyceride (glucose >110 mg/dl and triglyceride<151 mg/dl), 17/44 individuals are hypercholesterolemic. The Chi-Square value is 1.35< 3.88 under the 0.05 level of significance, and there is no significant difference in the number of cases with high cholesterol values > 150 mg/dl between the two different study groups.

In table (5) we checked the mean and standard deviation. The study found that in the 193 individuals having normal glucose <111 mg/dl and normal triglyceride <151 mg/d, the average cholesterol value was 186.3 mg/dl and the standard deviation was 32.41. While in the 112 individuals having high triglyceride >150 mg/dl and normal glucose <111 mg/dl, the average cholesterol value was 208.56 mg/dl and the standard deviation was 37.18. And in the 119 individuals having normal triglyceride < 151 mg/dl and high glucose >110 mg/dl, the average cholesterol value was 191.7 mg/dl and the standard deviation was 36.93. And in the 89 individuals having high glucose > 110 mg/dl and high triglyceride >150 mg/dl, the average cholesterol value was 207.29 mg/dl and the standard deviation was 44.79.

Further, the study in table (6) checked the presence of any correlation and hence, the regression considering the glucose as the independent variable and the cholesterol as the dependant one. The correlation coefficient value was 0.095 for all the 438 individuals that the study was conducted on. While with individuals having normal glucose <111mg/dl, the correlation coefficient value was 0.2. And with the group with glucose value 111-150 mg/dl, the correlation coefficient value was -0.006. And with the group with glucose value>150 mg/dl, the correlation coefficient value was 0.049. Likewise, the study in table (7) checked the presence of any correlation and hence, the regression considering the triglyceride as the independent variable and the cholesterol as the dependant one. The correlation coefficient value was 0.206 for all the 438 individuals that the study was conducted on. While with individuals having normal triglyceride <151mg/dl, the correlation coefficient value was 0.234 and with the group with triglyceride value 151-200 mg/dl, the correlation coefficient value was also 0.030 and with triglyceride value >200 mg/dl, the correlation coefficient value was- 0.038.

In both tables 6 and 7, the t test studied the regression slope at 5% level of significance under the assumption that the slope of the samples according to the different categories presented above is zero. In the glucose case, the test ratio for the t test for the slope (TR) in all the 438 individuals was 1.98. And in the category of glucose <111 mg/dl (TR) was 3.55 > 1.96. Thus a true forward relationship exists between the elevation in serum glucose and the elevation in serum cholesterol when test is done on the same sample from the same patient. Upon applying the same test into the next tow different glucose categories (Glucose is 111-150 mg/dl, Glucose is >150mg/d) (TR) was < 1.96, which is very small to reject our assumption. Thus in those 2 categorized cases, we accept our hypotheses that no true relationship exists between the elevation in serum glucose and the elevation in serum cholesterol sample according to table (6). In other words, in diabetic individuals, in each and every single sample, elevation in glucose does not necessarily, in the same manner, associate with elevation in cholesterol when test is done on the same sample from the same patient. Likewise, , what applies to table(6) goes exactly the same in table (7).The test ratio for the t test for the slope (TR) in all the 438 individuals was 10.36 . And in the category of triglyceride <151 mg/dl (TR) was 3.68 > 1.96. Thus in individuals with normal triglyceride level a true forward relationship exists between the elevation in serum triglyceride and the elevation in serum cholesterol in every single sample when test is done on the same sample from the same patient. While on applying the same test under the other 2 different triglyceride categories, (tg 151-200 mg/dl, tg>200 mg/dl) (TR) was < 1.96, which is small enough to reject our assumption. Thus in those 2 triglyceride categorized cases, we accept our hypotheses that in hypertriglyceremic individuals, no true forward or reverse relationship exists between the elevation in serum triglyceride and the elevation in serum cholesterol in every single sample when test is done on the same sample from the same patient. That means high level of triglyceride does not have to be associated with the same high cholesterol level in the same sample.

The study again was forwarded an other step by checking on table (8) the regression slope at 5% level of significance considering the triglyceride as the independent variable and the cholesterol as the dependant one for normoglycemic individuals who had normal glucose levels < 111mg/dl under the following categories: 1- All the 438 individuals, 2- Triglyceride is normal<150 mg/dl 3- Triglyceride is -151-200 mg/dl, 4- Triglyceride is >200 mg/dl .The correlation was 0.206, 0.250, 0.110,- 0.165 respectively. The test ratio for the t test for the slope (TR) in categories 1 and 2 was >2.

Thus in those categories, a true forward relationship exists between the elevation in serum triglyceride and the elevation in serum cholesterol in every single sample when test is done on the same sample from the same patient. While on the other 2 different categories, (tg 151-200 mg/dl, tg>200 mg/dl) (TR) was < 1.96, which is small enough to reject our assumption. Thus in those 2 triglyceride categorized cases, we accept our hypotheses that no true forward or reverse relationship exists between the elevation in serum triglyceride and the elevation in serum cholesterol in every single sample when test is done on the same sample from the same patient. That means, high level of triglyceride does not have to be associated with the same high cholesterol level in the same sample.

Discussion:

This retrospective study aims at further identifying the real effect of the elevation of serum glucose and serum triglyceride separately or in combination, on cholesterol levels in blood. The results in table (1) reveals that the synergistic elevation in both glucose and triglyceride whether moderate or high, has no association with increasing cases of elevated cholesterol in blood and thus has no clear effect on hypercholesterolemia. Table (2) declares the absence of any significant difference and hence, in hyperglycemic individuals high triglyceride level has the same impact of normal triglyceride on increasing cases of high cholesterol in blood. Same appears in table (3). The results show that in hypertriglyceridemic individuals, high glucose levels have the same impact of normal glucose on increasing cases of high cholesterol in blood. Thus we conclude that both glucose and triglyceride elevation have almost a negligible effect on the association with increasing cases of high cholesterol in blood. That last statement is confirmed by the results in table (4) where it shows an absence of any significant difference between the glucose elevation compared to the triglyceride elevation on the association with the number of cases with high cholesterol levels in blood. So glucose or triglyceride elevation or both, seem to have a limited impact on cases of blood cholesterol elevation. To confirm our findings we tested in table (5) the average of serum cholesterol values under the four categories: normal glucose and triglyceride, normal glucose high triglyceride, high glucose normal triglyceride, high glucose high triglyceride. It is clear from the results presented that the average cholesterol value is not significantly increasing with the elevation in glucose alone or the triglyceride alone or with both together elevation.

Last in tables (6-7-8) we tested the correlation and regression values. It is obvious that overall, with the whole number of the 438 individuals tested, both triglyceride and glucose values are relatively, positively correlated with cholesterol as we see from the correlation coefficient values. They varied between 0.095 for the glucose and 0.206 for the triglyceride. When both are normal, triglyceride and glucose values are relatively, positively correlated with cholesterol values. The correlation coefficient values became negligible when triglyceride and glucose were elevated over the normal ranges. That means, on diabetic or hypertriglyceremic patients, elevation in triglyceride and glucose is not correlated with cholesterol elevation.

Upon testing the hypothesis of a real forward or inverse relationship existence between the glucose and cholesterol or between triglyceride and cholesterol as for example, when one value of glucose or triglyceride goes up or down the corresponding cholesterol value goes in the same direction, we found that for the following categories: all the 438 individuals tested for the triglyceride, all the 438 individuals tested for the glucose, individuals with normal triglyceride < 151 mg/dl and individuals with normal glucose <111 mg/dl, the TR values (the test ratio for the t test for slope) were 10.36, 1.98, 3.68 and 3.55 respectively. We conclude so far, that there is a forward relationship exists between serum glucose and serum cholesterol elevation as a value to value, in the same sample. Same applies for the relation between serum triglyceride and serum cholesterol as a value to value, in the same sample. That was not the case with hyperglycemic or individuals having high triglyceride values. As it is shown from tables 6 , 7 and 8, all the values were less than 1.96. In those cases the values are far bellow the boundaries of the rejection region. So we accept our hypothesis: (the value of B which is the slope of each tested sample regression line is (0) and thus, no forward or inverse relationship exists between serum glucose and serum cholesterol as a value to value, in the same sample in diabetic individuals. Also no forward or inverse relationship exists between serum triglyceride and serum cholesterol as a value to value, in the same sample in individuals with hypertriglyceremia.

In conclusion: No association exists between serum glucose or triglyceride or both together elevation, and the increase cases of high blood cholesterol. In diabetic patients, no association exists between serum triglyceride elevation and the increase cases of high blood cholesterol.[4] In individuals having high triglyceride values, no association exists between serum glucose elevation and increase cases of high blood cholesterol. Individuals with high triglyceride or with hyperglycemia values, are equally matching each others in the number of cases of high blood cholesterol. From the data presented above, it is obvious that elevated cases of high cholesterol level in blood, seem to take an independent mode from elevation of both glucose and triglyceride levels whether separate or together. Last, from the data consisted of all the 438 individuals and in normoglycemic individuals, there is a forward relationship exists between serum glucose levels and serum cholesterol levels that are determined from the same sample. Same applies for the triglyceride, from the data consisted of all the 438 individuals and in individuals with normal triglyceride, there is a forward relationship exists between serum triglyceride values and serum cholesterol values that are determined from the same sample.

References:

1-Kannel WB, Gordon T, Castelli WP. Obesity, Lipids and glucose intolerance: the Framigham Study. Am J Clin Nutr 1979;32:1238-45

2-Esperanza R Briones, PhD, Dianne L Steiger, BS, PJ Palumbo, MD, et.al. Sterol excretion and cholesterol absorption in diabetics and nondiabetics with and without hyperlipidemia. The American Journal of Clinical Nutrition 44: SEPTEMBER 1986, pp 353-361.

3-Briones ER, Mao SJT, Palumbo PJ, O FaLLON wm, Chenoweth W, Kottke BA. Analysis of plasma lipids and apolipoproteins in insulin-dependent and noninsulin-dependent diabetics. Metabolism 1984;33:42-9.

4- Jinan B. Saaddine, MD; Michael M. Engelgau, MD; Gloria L. Beckles, MD; Edward W. Gregg, PhD; Theodore J. Thompson, MS; and K.M. Venkat Narayan, MD. A Diabetes Report

Card for the United States: Quality of Care in the 1990s. Ann Intern Med. 2002;136:565-574.

5- Lawrence S. Phillips, MD; William T. Branch Jr., MD; Curtiss B. Cook, MD; Joyce P. Doyle, MD; Imad M. El-Kebbi, MD; Daniel L. Gallina, MD; Christopher D. Miller, MD; David C. Ziemer, MD; and Catherine S. Barnes, PhD. Clinical Inertia. Ann Intern Med. 2001;135:825-834.

6-. Giles WH, Anda RF, Jones DH, Serdula MK, Merritt RK, DeStefano F. Recent trends in the identification and treatment of high blood cholesterol by physicians. Progress and missed opportunities. JAMA. 1993;269:1133-8. [PMID: 0008240474]

7-Cohen MV, Byrne MJ, Levine B, Gutowski T, Adelson R. Low rate of treatment of hypercholesterolemia by cardiologists in patients with suspected and proven coronary artery disease. Circulation. 1991;83:1294-304. [PMID: 0002013147].

8- T. O. Brien, T. T. Nguyen and B. R. Zimmerman. Hyperlipidemia and diabetes mellitus. *doi:* 10.4065/ 73.10.969 Mayo Clinic Proceedings October 1998 vol. 73 no. 10 969-976

9- Siraj ES; Seyoum B; Saenz C; Abdulkadir J. Lipid and lipoprotein profiles in Ethiopian patients with diabetes mellitus. Metabolism - 01-JUN-2006; 55(6): 706-10

A study of ALT Elevation in Association with Triglyceride, Cholesterol and Glucose Elevation in Human Serum

Abstract:

Obesity is a major health problem worldwide. It increases the risk of developing several chronic diseases, one of which is Nonalcoholic fatty liver disease (NAFLD), which is emerging as the most common chronic liver condition in the Western world (1). The disease is sometimes associated with mild elevation in the liver enzymes especially ALT (Alanin Amino transferase)(2). *This study aims at identifying among the three indicators glucose, cholesterol and triglyceride, the more influential, which, when elevated, may have an effect on or an association with ALT elevation. We found that, an association exists between elevated serum triglyceride, whether alone or in combination with high serum cholesterol and high serum glucose in one hand and the increase in the number of individuals who had high serum ALT >45 iu/ml as a response to that elevation. While elevated serum glucose or serum cholesterol separately did not seem to have the same influence. When in combination, they had the same effect of elevated serum triglyceride.*

Introduction:

The elevation of the liver enzyme *ALT* (Alanin Amino Transferase) is usually associated with some liver damage. By excluding the drug related ALT elevation and the viral factors such as hepatitis A, B and C, which can cause liver damage and are associated with elevation in serum *ALT*, nonalcoholic fatty liver disease (NAFLD) is considered one of the major liver diseases, sometimes associated with mild elevation in *ALT*. It describes a range of conditions involving the liver that affect people who drink little alcohol or are nonalcoholic. Obesity on the other hand, one or more abnormal cholesterol levels — high levels of triglycerides, and resistance to insulin are considered the most important factors that cause NAFLD. (1,2).

In the light of the aforesaid facts, we assume that type 2 diabetes, high serum cholesterol and triglyceride, whether separate or in combination, could have a damaging effect on liver cells which is manifested in fatty liver and may be associated with ALT elevation. The purpose of this study is to detect this elevation in serum ALT on obese human subjects in response to high serum glucose, cholesterol and triglyceride, each in separate case or in combination, after excluding drug related ALT elevation and cases of elevated *ALT* due to hepatitis A, B and C.

Review of literature:

Obesity is a major health problem worldwide. In the United States, roughly 300,000 death cases per year are related to obesity. Obesity also increases the risk of developing several chronic diseases such as type 2 diabetes, insulin resistance, coronary heart disease (responsible for heart attacks), cerebrovascular disease (responsible for strokes), high blood pressure, gout, gallstones, colon cancer, sleep apnea, and nonalcoholic fatty liver disease (NAFLD). (2).

Nonalcoholic fatty liver disease on the other hand, is emerging as the most common chronic liver condition in the West. It is associated with insulin resistance (2,3). Fatty liver or NASH (Nonalcoholic steatohepatitis) is very common among overweight persons over the age of 30. Fatty liver contains an excessive amount of fat. In such a liver, liver cells and the spaces in the liver are filled with fat so the liver becomes slightly enlarged and heavier(4). There may also be elevation of the liver enzymes.

Fatty liver may cause no damage, but sometimes the excess fat leads to inflammation of the liver(4). Disease presentation ranges from asymptomatic elevated liver enzyme levels to cirrhosis(1,5) with complications of liver failure and hepatocellular carcinoma (1,5).

Epidemiology of NAFLD:

Hepatic steatosis detected by magnetic resonance spectroscopy is found in 31% of adults in the United States. Ultrasonography detects fatty changes in the liver in 12.9%–16.4% of individuals. NAFLD is more frequent among people with diabetes (50%) and obesity (76%) (3,5), and it is almost universal among diabetic people who are morbidly obese. More than 6 million children in the United States have the fatty liver disease(6). Patients who have NAFLD appear to have a higher mortality than people in the general population. Patients with pure steatosis have a benign prognosis: follow-up of 198 patients for up to 21 years revealed progression to cirrhosis in 3 patients and liver-related death only in one case. In contrast, up to 11% of NASH patients may die of liver-related causes. Diabetes is a risk factor for fibrosis progression and for overall and liver-related death among NAFLD patients. (3). The presence of obesity or type 2 diabetes mellitus are the strongest predictors of liver fibrosis (7). Around 16% of autopsy studied in patients with type 2 diabetes showed liver cirrhosis indicating that high prevalence of this disorder(8).

Risk factors of NAFLD:

1-Overweight and Obesity: More than 70 percent of people with nonalcoholic steatohepatitis (NASH) are obese(2,4,5).

2- Diabetes: As many as three out of four people with NASH also have diabetes(4,5).

3- Hyperlipidemia: High cholesterol levels and elevated triglycerides are common in people who develop NASH (5). It's estimated that up to 80 percent of people with NASH have hyperlipidemia. (4,5).

Materials and Methods:

The sample consisted of 245 of both males and females who attended our laboratory between Sep 2007 and Apr 2008 and had their serum ALT detected. Having the attitude to develop a (large belly) in both males and females in our region of study, we came to consider the abdominal obesity index and not the body mass index as our obese subjects chosen index. Therefore, the cut-off criteria which has been proposed to define obesity in our study group was the (waist circumference ≥ 85 cm)(5). All individuals who had waist circumference< 85 cm were excluded from the study.

All participants were screened for negative hepatitis A, B and C (by doing Anti HCV, HbsAg, Anti HAV IgM) and questioned for not taking any drug that can interfere with ALT elevation. Out of the 245 individuals, serum fasting glucose was done on145, serum cholesterol on 151 and serum triglyceride on 163 individual. Each statistical sample studied was divided into two groups considering the upper normal value as the cut off point in group partition. e.g.(one group with high serum levels of triglyceride versus the other group with normal levels). Then, a comparison study was conducted on the effect of the elevated level of each of the three parameters (Glucose, Cholesterol and Triglyceride) on the ALT elevation as follows:

1- One study measures elevated cases of serum ALT > 45 iu/ml in group one having high serum glucose level > 110 mg / dl versus group two with normal serum glucose < 110 mg/dl.

2- An other study measures elevated cases of serum ALT > 45 iu/ml in group one having high serum cholesterol > 200 mg /dl versus group two with normal serum cholesterol<200 mg/dl.
3- A third study measures elevated cases of serum ALT > 45 iu/ml in group one having high serum triglyceride>150 mg/dl versus group two with normal serum triglyceride <150 mg/dl.
4- A fourth study measures elevated cases of serum ALT > 45 iu/ml in group one having high serum triglyceride>150 mg/dl versus group two with combined high serum triglyceride and high serum glucose levels and group three with combined high serum triglyceride, high serum glucose and high serum cholesterol.
5- A fifth study measures elevated cases of serum ALT > 45 iu/ml in group one having high serum triglyceride>150 mg/dl versus group two with combined high serum cholesterol and high serum glucose.

Analysis:

We used the Chi-Square test as a means of comparing the results according to the following null hypotheses: The total number of elevated cases of ALT values > 45 iu/ml in the different study groups is equal under 0.05 level of significance.

The alternative hypotheses: The total number of elevated cases of ALT Values > 45 iu/ml in the different study groups is not equal under 0.05 level of significance.

Results and Tables:

1- Table (1) shows the number of cases with high serum ALT > 45 iu/ml in group- one with high serum glucose versus group- two with normal serum glucose levels.

Glucose	Total # of tested cases	# of cases with ALT >45 iu/ml	Expected # of cases with ALT >45 iu/ml	Chi-Square value
Glucose >110	74	12	11	0.171
Glucose< 110	80	11	12	
Total	154	23		

Table (1) indicates that the Chi-Square value is 0.171< 3.84 under the 0.05 level of significance, which means that the null hypotheses is acceptable: there is no significant difference in the number of cases with high serum ALT values > 45 iu/ml in both study groups (high serum glucose and normal serum glucose) under 0.05 level of significance.

2- Table (2) shows the number of cases with high serum ALT > 45 iu/ml in group-one with high serum cholesterol versus group-two with normal serum cholesterol levels.

Cholesterol	Total # of tested cases	# Of cases with ALT >45 iu/ml	Expected # of cases with ALT >45 iu/ml	Chi-Square value
Cholesterol>200	36	5	5	0
Cholesterol<200	115	17	17	
Total	151	22	22	

Table (2) indicates that the Chi-Square value is 0.0< 3.84 under the 0.05 level of significance, which means that the null hypotheses is acceptable:

there is no significant difference in the number of cases with high serum ALT values > 45 iu/ml in both study groups (high serum cholesterol and normal serum cholesterol) under 0.05 level of significance.

3- Table (3) shows the number of cases with high serum ALT > 45 iu/ml in group-one with high serum triglyceride versus group-two with normal serum triglyceride levels.

Triglyceride	Total # of tested cases	# Of cases with ALT >45 iu/ml	Expected # of cases with ALT >45 iu/ml	Chi-Square value
Triglyceride>150	66	15	10	4.166
Triglyceride<150	97	10	15	
Total	163	25		

Table (3) reveals that the Chi-Square value is 4.166> 3.84 under the 0.05 level of significance, which means that the null hypotheses: there is no significant difference in the number of cases with high serum ALT values > 45 iu/ml in both study groups (high serum triglyceride and normal serum triglyceride) under 0.05 level of significance is inapplicable and the null hypotheses is rejected. We accept the alternative hypotheses: The number of cases with high serum ALT values > 45 iu/ml in both study groups is not equal under 0.05 level of significance.

4-Table (4) shows the number of cases with high serum ALT > 45 iu/ml in group- one with high serum triglyceride versus group- two with combined high serum triglyceride and high serum glucose and group three with combined high serum triglyceride, glucose and cholesterol.

Elevated Tg compared to elevated cho, tg, glu	Total # of tested cases	# Of cases with ALT >45 iu/ml	Expected # of cases with ALT >45 iu/ml	Chi-Square value
Tg > 150	66	15	14	0.46
	33	6	7	
Glu>110, tg>150 Tg>150, Glu>110 Cho> 200	20	5	4	

Table (4) indicates that Chi-Square value is 0.46 < 5.99 under the 0.05 level of significance, which means that we accept the null hypotheses: there is no significant difference in the number of cases with high ALT values > 45 iu/ml in the three different study groups (high triglyceride > 150 mg / dl, combined high triglyceride> 150 mg/dl and high glucose > 110 mg/dl, combined high triglyceride, high glucose>110 mg/dl and high cholesterol >200 mg/dl) under 0.05 level of significance.

5-Table (5) shows the number of cases with high ALT > 45 iu/ml in group-one with high serum triglyceride versus group-two with combined high serum cholesterol and high serum glucose.

Elevated triglyceride compared to elevated	Total # of tested cases	# Of cases with ALT >45 iu/ml	Expected # of cases with ALT >45 iu/ml	Chi-Square value

cholesterol and glucose				
Triglyceride>150	66	15	12	2.4
Glu>110, cho>200	45	5	8	
Total	111	20		

Table (5) reveals that the Chi-Square value is 2.40 < 3.84 under the 0.05 level of significance, which means that we accept the null hypotheses: The total number of cases of high serum ALT values > 45 iu/ml in both the study groups (high triglyceride > 150 mg / dl, combined high cholesterol> 200 mg/dl and high glucose > 110 mg/dl,) is equal under 0.05 level of significance.

Discussion:

This study aims at revealing the importance of those major risk factors, which are high serum glucose, high serum cholesterol and high serum triglyceride levels among the obese targets and there association with the liver enzyme ALT (Alanin Amino Transferase) elevation. Through that we estimate their impact on nonalcoholic fatty liver disease (NAFLD). We have tried our best to restrict ourselves to those factors by excluding other variables which contribute to serum ALT elevation e.g. (A, B, C hepatitis) and drug related cases on our defined obese subjects with their waist circumference> 85 cm. In order to achieve more accuracy, we have chosen to do this study by separately working on a single variable first, e.g. (glucose, cholesterol, triglyceride), then the study combined the different variables to evaluate the combination effect of those variables.

On going back to table (1). Chi-Square value was only 0.171 which is close to 0. Our findings show that elevated serum glucose > 110-mg/ dl alone has no direct impact on or association with increasing cases of high serum ALT . Thus we conclude that high levels of serum glucose alone has no association with elevated cases of serum ALT.

The same applies to cholesterol as our results in table (2) with the Chi-Square value (0) indicate that there is no direct correlation between the elevated serum cholesterol > 200 mg / dl alone and the increase number of individuals with high serum ALT. Thus we conclude that high levels of serum cholesterol alone has no association with elevated cases of serum ALT.

Our interesting finding appears in table (3). It indicates that high serum triglyceride > 150 mg / dl by itself has a strong impact on and association with increasing the number of cases with high serum ALT> 45 iu/ml, hence causing more damage to the liver (6). Thus we conclude that high levels of serum triglyceride is associated with serum ALT elevation .This finding is in consistent with and supports what is written in risk factor above. “It's estimated that up to 80 percent of people with NASH have hyperlipidemia.”

Our previous findings in table (3) are supported with the results shown in table (4) as we found that the combining effect of high serum cholesterol or high serum glucose or both together with high serum triglyceride did not add more impact to what high serum triglyceride alone had on the increasing cases of high serum ALT.

Elevated serum triglyceride by itself is associated with increase cases of serum ALT elevation and thus may have a rule to play in NAFLD while the other two factors elevation when they are separately elevated have a limited rule if at all.

At the end, we were interested in evaluating the association of high serum triglyceride alone in contrast to samples having (serum cholesterol and serum glucose simultaneously elevated) with serum ALT elevation. Surprisingly, we found in table (5) that both synergistically elevated serum cholesterol and glucose have the same high triglyceride impact. This finding can be explained by many studies, one of which is done by us and shows that (the combination of high serum cholesterol and serum glucose in blood is usually associated with increase cases of high serum triglyceride in blood). That leads us again to the emphasis on the importance of high serum triglyceride on ALT elevation and thus its impact on NAFLD.

In conclusion:

This study declared that high triglyceride, regardless of its association with the elevation in glucose or cholesterol or both, has a rule to play in fatty liver disease development and progress. The elevation of triglyceride in blood can cause harm to the hepatocytes (1) due, among other factors, to its association with the enzyme ALT elevation. High blood glucose or high blood cholesterol alone, in this study, on the other hand, did not show any significant effect on ALT elevation. The equivalent effect of the combination of both high glucose and high cholesterol to the effect of high triglyceride on ALT elevation is justified not only by their combined effect on elevating ALT but indirectly, on elevating triglyceride as well, which by itself causes the elevation in ALT.

Sum m ary

Introduction and objectives: One of the common liver diseases nowadays in the world is Non Alcoholic Fatty Liver Disease (NAFLD). This disease is caused as a result of many factors. Obesity, insulin resistant diabetes, cholesterol components disturbance and elevation of triglyceride are considered the most important causes of this disease. In early stages, the disease may associate with elevation in liver enzymes; one of the major elevated enzymes is the (ALT) (Alanin Amino transferase) enzyme.

Accordingly, it is justified to assume that an elevation of one of the blood figures glucose, cholesterol and triglyceride or their combination after excluding the viral hepatitis factors and the drug related ALT elevation, will have a major effect on increasing the number of cases of elevated (ALT) in blood. This in itself is the reason behind this study, which aimed at defining:

1- The existence of an association between (the group having high glucose levels versus the group having normal glucose) and the increase in the number of cases of elevated serum ALT in blood.
2- The existence of an association between (the group having high cholesterol versus the group having normal cholesterol) and the increase in the number of cases of elevated serum ALT in blood.
3- The existence of an association between (the group having high Triglyceride versus the group having normal triglyceride) and the increase in the number of cases of elevated serum ALT in blood.
4- The existence of an association among (the group having high Triglyceride versus the group having combined high triglyceride and high glucose and the group having triglyceride, glucose and cholesterol elevated) and the increase in the number of cases of elevated serum ALT in blood.

5- The existence of an association between (the group having high Triglyceride versus the group having combined high cholesterol and high glucose) and the increase in the number of cases of elevated serum ALT in blood.

<u>*Methods*</u>: The sample consisted of 245 of both males and females who had their serum ALT detected after defining the obesity in the study group as the: (waist circumference ≥ 85 cm) and all the participants were screened for negative hepatitis A, B and C. In each study case the sample was divided into two groups normal and abnormal. A comparison study was conducted on the effect of the elevated level of each of the three parameters (Glucose, Cholesterol and Triglyceride) on ALT elevation. Chi-Square test was used as a mean of comparing the results.

<u>*Results*</u>: The tables (1,2) showed that, when compared to normal levels, high glucose or high cholesterol showed no significant difference in increase cases of high ALT in blood > 45 iu / ml. On table (3) when triglyceride was elevated in blood > 150-mg/ dl, the condition was changed, as that elevation was associated with an increase in the number of cases of high ALT in blood. On table (4) the combination of high glucose and cholesterol or high glucose, cholesterol and triglyceride when compared to high triglyceride alone did not show any significant difference in elevated cases of high ALT in blood. Table (5) reveals that the combination effect of both high cholesterol and high glucose is equivalent to the high triglyceride effect on the increase in the number of cases of high ALT in blood.

<u>*Conclusion*</u>: The results showed that high triglyceride, regardless of its association with the elevation in glucose or cholesterol or both, has a rule to play in fatty liver disease development and progress. The elevation of triglyceride in blood can cause harm to the hepatocytes due to its association

with the enzyme ALT elevation. High glucose or high cholesterol alone on the other hand, did not show any significant effect on ALT elevation. The equivalent effect of the combination of both high glucose and high cholesterol to the effect of high triglyceride on ALT elevation is justified not only by their direct effect on elevating ALT but indirectly on elevating triglyceride which by itself causes the elevation in ALT.

References:

1- Katerina Bogdanova, Hana Poczatkova, et-al. NON-ALCOHOLIC FATTY LIVER DISEASE (NAFLD) – A NOVEL COMMON ASPECT OF THE METABOLIC SYNDROME. Biomed Pap Med Fac Univ Palacky Olomouc Czech Repub. 2006, 150(1):101–104.

2- NC McAvoy, A Lockman, PC Hayes. Non alcoholic fatty liver disease (NAFLD):an overview. J R Coll Physicians Edinb 2007; 37:9–17 © 2007 Royal College of Physicians of Edinburgh

3- Leon A. Adams, Paul Angulo and Keith D. Lindor. Nonalcoholic fatty liver disease. CMAJ • March 29, 2005; 172 (7). doi:10.1503/cmaj.045232. © 2005 CMA Media Inc. or its licensors Review Synthèse

4- Mayo Clinic Staff. Nonalcoholic fatty liver disease Feb 19, 2007. MayoClinic.com. Mayo Foundation for Medical Education and Research

5- AS Dabhi*, KJ Brahmbhatt*, TP Pandya*, PB Thorat**, MC Shah***. Non-Alcoholic Fatty Liver Disease (NAFLD). JIACM 2008; 9(1): 36-41.

6-Perrie E. Pardee, B.S.; Joel E. Lavine, M.D., Ph.D.; Aaron K. Blumkin, M.S.; and Stephen Cook, M.D. Fatty liver disease may raise heart disease risk in overweight, obese kids. American Heart Association. December 15, 2008. NR08 – 1078 (Circ/Schwimmer)

7-Hong Kong: Ethics Committee. Non Alcoholic Fatty Liver Disease (NAFLD) in Hong Kong. ClinicalTrials.gov. June 17, 2008. UW 05-120 T/783, HARECCTR0500006, KW/EX/05-036

8- Dr NC McAvoy, Dr KA Lockman, Professor P Hayes Non alcoholic fatty liver disease (NAFLD): a waist problem. Royal College of Physicians of Edinburgh and Royal College of Physicians and Surgeons of Glasgow. First published: October 2007 .