IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.53
Volume 4, Issue 1, June 2024

Generalized Synchronization of Different Chaotic System via Linear Mapping

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Abstract: *A generalized approach for constructing chaotically synchronized Shimizu Morioka system via linear transformations is proposed . Proposed method is much simpler than the method proposed by Pecora and Carroll (1990) . This method is very useful for synchronization of hyper-chaotic system because Lyapunov exponents need not required to calculate .This method can predict the responding system's behaviour by knowing the driving system's*

Keywords: Generalized Synchronization ; Shimizu Morioka system; Linear transformations

I. INTRODUCTION

Chaotic system are dynamical system that are highly sensitive to initial condition . In 1990 , Pecora and Carrol to introduced the chaos synchronization idea . Synchronization of chaotic systems is a phenomenon that may occur when behavior of two or more coupled chaotic systems are closely related . Since then much attention has been accepted because of it's fundamental importance in non linear dynamics and application in many fields such as information processing , electronic circuit , secure communication , biological and chemical system etc . There are many types of synchronization , depending on whether the motions are identical or just related in some patterned way . Identical synchronization between two dynamical systems ,which states that as time tends converge to zero .In 1995 , Rulkov , Succhik and Tsimring generalized this concept for unidirectionally coupled dynamical systems . According to them ,of a static functional relation exists between the states of the systems , it is generalized synchronization (GS) . Kocarev and Parlitz (1996) formulated a condition for the occurrence of GS for the following systems

$$\dot{x} = f(x) \qquad \text{driving system}$$
$$\dot{y} = g(y,u) = g(y,h(x)) \qquad \text{driven system} \qquad (1)$$

where $x \in R^n$, $y \in R^n$ and $u(t) = (u_1(t) , u_2(t) ,\ldots\ldots u_k(t))$ with $u_j(t) = h_j(x(t(x_0))$. Here the variables u_j are introduced to the include explicitly the case that a function $u = h(x)$ of x is used for driving the response system . According to Kocarev and Parlitz the system in (1) possess the property of property of GS between x and y if there exists a transformation $H: R^n \rightarrow R^m$, a manifold

M = $((x,y): y = H(x))$, and a subset $B = B_x \times B_y \subset R^n \times R^m$ with $M \subset B$ such that all trajectories of (1) with initial conditions in the basic approach M as time t goes a infinity . If H equals the identity transformation , the definition of generalized synchronization coincides with the usual definition of synchronization e.g.; identical synchronization , GS is more useful for analysing real world phenomenon .

To design a channel-independent chaotic secure communication Yang and Chua (1996) applied generalized synchronization . In generalized synchronization , of the synchronizing manifold is linear it is called linear generalized synchronization . Poria (2007) studied the linear generalized synchronization of chaotic Lorenz system . In this paper, synchronization of chaotic trajectories of unidirectionally coupled Shimizu-Morioka systems via linear transformation . To show the efficiency of this method numerical simulation results are presented .

II. LINEAR GENERALIZED SYNCHRONIZATION

A dynamical system can be decomposed into two parts

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$\dot{x}$ =Ax+$\psi(x)$ (2)

Where A is an n $\times$ n constant matrix and $\psi : R^n \rightarrow R^n$. We assume that the driving system transmit the signal $\psi(x)$ to the driven system and consider the following unidirectional synchronization scheme :

$\dot{x} = Ax + \psi(x)$ driving system

$\dot{y} = Ay + \lambda\psi(x)$ driven system (3)

here is an n$\times$ n matrix .

THEOREM . If the matrix λ commutes with A , then the two dynamical systems in (3) are in a state of generalized synchronization via the following generalized synchronization transformation

$$Y(\infty) = H(x) = \lambda x \quad (4)$$

if and only if all eigenvalues of the matrix A have negative real parts .

Proof : Let z = y – λx , then the stability of the GS between the two dynamical system in (3) via the GS transformation y = H(x) = λx is equivalent to that of the following system :

$\dot{z}$ = [Ay + $\lambda\psi(x)$] – [λ Ax + $\lambda\psi(x)$]

= Ay – λAx

= A (y- λx) since λ commutes with A

= Az . **(5)**

Therefore z = 0 is asymptotically sable if and only if all eigen values of the matrix A have negative real parts .

The matrices x which commutes with an n$\times$ n matrix A must be an n$\times$ n matrix which satisfies the Following equation :

$$Ax = xA \quad (6)$$

Clearly the above equation has infinite number of solutions, therefore we can construct several methods of linear GS between two chaotic systems . In this paper we discuss the following two types of solutions of the equation (6) , (i) λ = A + A^{-1} (ii) λ = adj A

III. GENERALIZED SYNCHRONIZATION OF SHIMIZU – MORIOKA SYSTEMS .

In this section we study the linear GS of two Shimizu – Morioka systems . Shimizu Morioka proposed the following system which is known as Shimizu – Morioka system .

$\dot{x}$ = y

$\dot{y}$ = x - βy –xy

$\dot{z}$ = αz + x^2 (7)

where α ,β are two positive parameters . This system contains two non - linear term xy, x^2 .

The Shimizu – Morioka system can be decomposed into two parts as

$\dot{x}$ = Ax + $\psi(x)$ (8)

where $A = \begin{bmatrix} -1 & 1 & 0 \\ 0 & -\beta & 0 \\ 0 & 0 & -\alpha \end{bmatrix}$ (9)

$\psi(x) = \begin{pmatrix} x \\ x - xy \\ 2\alpha z + x^2 \end{pmatrix}$ and $\mathbf{x} = \begin{pmatrix} x \\ y \\ z \end{pmatrix}$

clearly the matrix A will be negative definite if $\alpha > 0, \beta > 0$. Now , if the driven system is

$\dot{y}$ = Ay + $\lambda\psi(x)$ (10)

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where the matrix λ commutes with A then the driving Shimizu–Morioka system (8) and the driven Shimizu – Morioka system (10) are in a state of generalized synchronization .

IV. RESULTS AND DISCUSSIONS

SIMULATION 1. In this case , we take

$$\lambda = \begin{bmatrix} -2 & 1-1/\beta & 0 \\ 0 & -\beta-1/\beta & 0 \\ 0 & 0 & -\alpha-1/\alpha \end{bmatrix} \qquad (11)$$

where $\lambda \neq 0$. Clearly A = Aλ . Therefore all conditions for synchronization are satisfied . Here the driving Shimizu Morioka system is (8) and the driven Shimizu Morioka system is given by

$$\dot{\bar{x}} = -\bar{x} + \bar{y} - (1 + 1/\beta)\,x - (1 - 1/\beta)\,xy$$
$$\dot{\bar{y}} = -\beta\bar{y} - (\beta + 1/\beta)x + (\beta + 1/\beta)xy$$
$$\dot{\bar{z}} = -\alpha\bar{z} - (2\alpha^2 + 2)z - (\alpha + \tfrac{1}{\alpha})x^2 \qquad (12)$$

the driving system and the driven system are connected by linear transformations .

$$\bar{x} = -2x + (1-1/\beta)\,y$$
$$\bar{y} = -(\beta + 1/\beta)y$$
$$\bar{z} = -(\alpha + 1/\alpha)z \qquad (13)$$

SIMULATION 2 . In this case , we choose

$$\lambda = \begin{bmatrix} \alpha\beta & \alpha & 0 \\ 0 & \alpha & 0 \\ 0 & 0 & \beta \end{bmatrix} \qquad (14)$$

Clearly the matrix λ commutes with A . In this case , the driven Shimizu Morioka system is given by

$$\dot{\bar{y}} = -\beta\bar{y} + \alpha x - \alpha xy$$
$$\dot{\bar{z}} = -\alpha\bar{z} + 2\alpha\beta z + \beta x^2 \qquad (15)$$

If the GS between the driven and driving system is achieved , the following relations should be satisfied

$$\bar{x} = \alpha\beta x + \alpha y$$
$$\bar{y} = \alpha y$$
$$\bar{z} = \beta z \qquad (16)$$

Study Duration: November 2014 to November 2015.
Sample size: 300 patients.
Sample size calculation: The sample size was estimated on the basis of a single proportion design. The target population from which we randomly selected our sample was considered 20,000. We assumed that the confidence interval of 10% and confidencelevel of 95%. The sample size actually obtained for this study was 96 patients for each group. We planned to include 300 patients (Group I- Control, Group II- Cases of 100 patients for each group) with 4% drop out rate. (10)
Subjects & selection method: The study population was drawn from consecutive diabetic patients who presented to Dr. Ram Manohar Lohia Combined Hospital with dyslipidemia and were prescribed the indicated statins and underwent fasting blood test of lipid profile before statin treatment initiation between from November 2014 to November 2015. Patients were divided into three groups (each group had 100 patients) according to doses of statins. The prescribed doses of statin in RMLH for diabetic patients (10)
With dyslipidemia were as follows:
Group A(N=100 patients) -Atorvaststin 40mg daily to each patients;

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Group B (N=100 patients) -Rosuvastatin 20mg daily to each patients; and
Group C (N=100 patients) -Rosuvastatin 20 mg to each patients at alternative days.

Inclusion criteria:
Diabetic patients (fasting blood glucose ≥ 126 mg/dL [7.0mmol/L])
Either sex
Aged ≥ 18 years,
Patients have a total cholesterol level of ≥154.68 mg/dl , LDL-C 96.6 mg/dl, HDL-C ≤ 138.6 in men and ≤46.3 mg/dl in women.
Fasting triglycerides ≥ 150.56 mg/dl, obtained within 1 week before the first use of statins which was then compared at first- and second-year intervals. (10)

Exclusion criteria:
Pregnant women;
Patients with genetic disorders
Patients on other concurrent lipid lowering agents such as bile acid sequest
rants (cholestyramine, colesevelam), niacin, ezetimibe, fenofibrate and/or omega 3.
Patients with previous history of angina, severe vascular disease, or other life threatening disease.
Patients with nephropathy and/or hypothyroidism, active liver disease, bile duct problems, or ALT > 3 × ULN.
Patients with creatine kinase levels > 10 × ULN.
Patients taking concurrent corticosteroids, ciclosporin, and/or hormone replacement therapy.
Patients who are physically inactive.
Patients with a history of drug or alcohol abuse. (10)

Procedure methodology
After written informed consent was obtained, a well-designed questionnaire was used to collect the data of the recruited patients retrospectively. The questionnaire included socio-demographic characteristics such as age, gender, nationality, height, weight, and consanguineous marriage, physical activity and lifestyle habits like smoking and alcohol and statin prescribed for at least 2 years continuously and dose, type of DM, its duration, and clinical and biochemistry laboratory investigations such as fasting bloodglucose, glycated hemoglobin (HbA1C), total cholesterol, HDL and LDL cholesterol levels, and TGs. (10)
All lipid parameters were quantified on samples collected in the fasting state. Cholesterol and TG quantization was determined by enzymatic assay. LDL-C was calculated using the Friedewal dequation for patients with TG ≤ 400 mg/dl and measured by b-quantification for those with TG > 400 mg/dl. Levels of non-HDL-C were calculated by subtraction of HDL-C from total cholesterol. (10)
Information about the type of statin (rosuvastatin, atorvastatin) was taken from the pharmacy database. Baseline characteristics of the patients were collected from the database 1 week before the first use of statins. . Height and weight were measured using standardized method. The body mass index (BMI) was calculated as the weight in kilograms (with 1 kg subtracted to allow for clothing) divided by height in meters squared. (10)
Blood pressure was recorded using an electronic instrument (Model: HEM-7101, Omron Corporation, Tokyo, Japan) as the mean of two readings taken five minutes apart. (10)

The prescribed doses of statin in RMLH for diabetic patients with dyslipidemia wereas follows:
Group A-Atorvaststin 40mg;
Group B -Rosuvastatin 20mg; and
Group C -Rosuvastatin 20 mg at alternate days. (10)
Fasting capillary blood glucose [CBG] was determined by using One Touch Ultra glucose meter (Johnson & Johnson, Milpitas, California) after eight hours of overnight fasting. A fasting venous sample was collected and lipids were measured. (10)

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All biochemical assays was carried out by the same team of laboratory technicians using the same method, throughout the study period. The samples were assayed for total cholesterol, triglycerides and HDL cholesterol.

Serum cholesterol (cholesterol esterase oxidase-peroxidase-amidopyrine method), serum triglycerides (glycerol phosphate oxidase-peroxidase-amidopyrine method), and high-density lipoprotein cholesterol (direct method poly-ethylene-glycol-pretreated enzymes) was measured using the Beckman Coulter AU 2700/480 Autoanalyser (Beckm an AU [Olympus], Ireland). The intra– and inter-assay coefficients of variants (CV) for the biochemical assays ranged from 3.1% to 7.6%. (10)

In every subject, a semi-quantitative food frequency questionnaire was administered to collect detailed information on dietary intake over the past year. Dietary fat and oil intake was assessed as the amount of fat/oil used during cooking and/or added at the table.

Statistical analysis

Data was analyzed using SPSS version 20 (SPSS Inc., Chicago, IL). Student's *t*-test was used to ascertain the significance of differences between mean values of two continuous variables and confirmed by nonparametric Mann-Whitney test. In addition, paired *t*-test was used to determine the difference between baseline and 2 years after regarding biochemistry parameters, and this was confirmed by the Wilcoxon test which wasa nonparametric test that compares two paired groups. Chi-square and Fisher exact tests were performed to test for differences in proportions of categorical variables between two or more groups. The level $P < 0.05$ was considered as the cutoff value or significance. (10)

Result

After 6 weeks of follow upmit was found that LDL-C ,went down by -32.81%on regular dose of Atorvastatin 40 mg,-37.28% on Rosuvastatin 20 mg daily and -37.53% on Rosuvastatin 20 mg alternate day.

The total Cholestrol level reduced by -14.71%,17.35%,-11.63%,respectively.

Trigyceride level reduced by -14.71%,17.3%,11.^3%, respectively.

Non HDL-C went down by -37.32%,29.715% and -29.71% respectively.

HDL-C improved by +3.46%,+8.17%and 8.17%,respectively. (10)

Table no 1 Shows metabolic parameters of patients of the three groups before treatment. Total cholesterol (TC), 224.3 ±30.8 mg/dl, 226.1 ±35.4&225.3 ±40.7 mg/dl, LDL-C, 158.3 ±22.6 mg/dl, 156.1 ±27.8&157.2 ±26.7 mg/dl, HDL-C, 37.5 ±2.70 mg/dl, 35.5 ±2.21&36.4 ±1.90 mg/dl, Triglyceride165.8 ±30.8 mg/dl, 162.6 ±28.2&166.8 ±35.7mg/dl, Non-HDL-C 180.6 ±31.2 mg/dl, 182.4 ±29.2 & 185.2 ±32.4 mg/dl, , FBG, 142.5 ±25.7 mg/dl, 148.2 ±26.9 & 145.8 ±27. mg/dl4, HbA1c, %, 5.82 ±0.2, 5.62±0.4 & 5.65 ±0.3 respectively of patients of the three groups. The difference in the values of all parameters in respect of three groups was not statistically significant (p>0.05) (10)

Table 1: Shows metabolic parameters of patients of the three groups before treatment. (10)

	Atorvastatin 40 mg	Rosuvastatin 20mg	Rosuvastatin 20 mg alternate day	P value (I to II)	P value (I to III)	P value (II to III)
Lipids, mg/dL						
Total Cholesterol (TC)	224.3±30.8	226.1±35.4	225.3±40.7	0.7017	0.8449	0.8449
LDL-C	158.3±22.6	156.1±27.8	157.2±26.7	0.5399	0.7535	0.7757
HDL-C	37.5±8.70	35.5±9.21	36.4±7.90	0.357	0.487	0.389
Triglyceride	165.8±30.8	162.6±28.2	166.8±35.7	0.4444	0.8323	0.3570
Non-HDL-C	180.6±31.2	182.4±29.2	185.2±32.4	0.6740	0.3077	0.5216
Glucose and HbA1C						
FBG, mg/dL	142.5±25.7	148.2±26.9	145.8±27.4	0.1271	0.3808	0.5327
HbA1c, %	5.82±0.2	5.62±0.4	5.65±0.3	0.265	0.357	0.647

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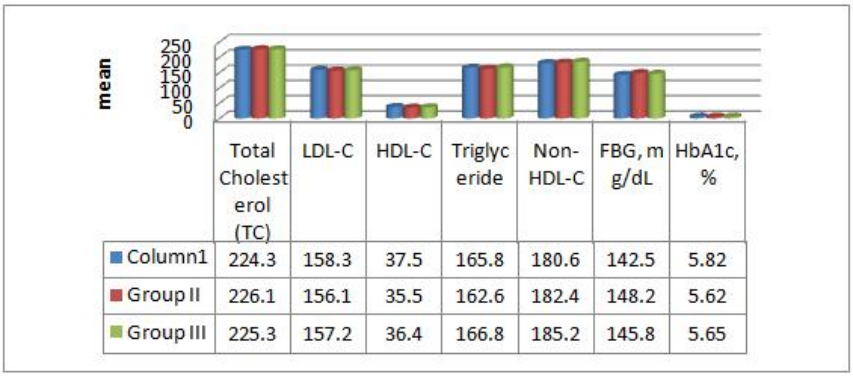
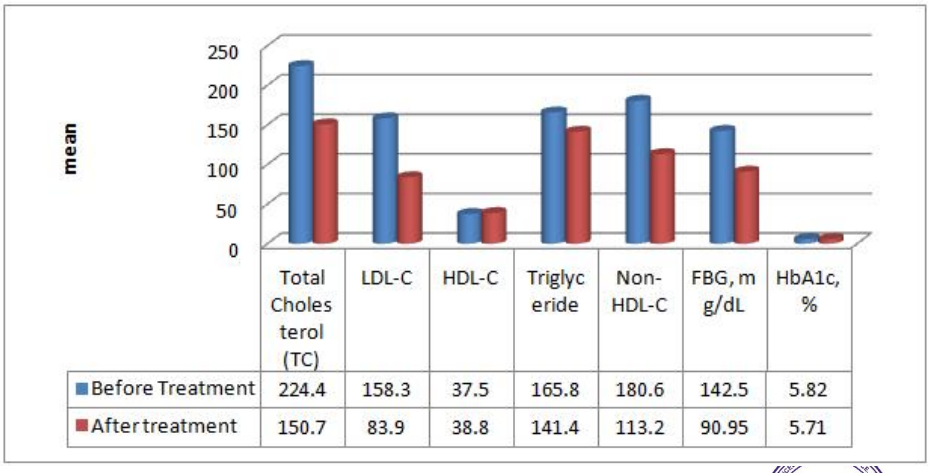


Follow up after 6 weeks (10)

Table no 2: Records the percent change in lipids,(mg/dL) on a regular dose of atorvastatin40 mg.for 6weeks. (TC)level reduced by(-32.81%), low-density lipoproteins cholesterol(LDL-C)went down by(-46.99%),triglycerides reduced by by(-14.71%), non-HDL-C went down by(-37.32%).While there had been a reduction in the undesirable Lipids, as above, due to the above medication ,there was a positive upwards change in the desirable lipids like high-density lipoprotein cholesterol (HDL-C) which improved by(+3.46%).Further, Fasting blood glucose (FBG) mg/dL level were reduced by (-36.17%).and HbA1c, % hemoglobin A1C test which measures blood sugar control over the preceding three months had also gone down by(-1.89%). The desirable alterations in respect of all the above parameters after 6 weeks of medication which are attributable to the above medication, were highly statistically significant, P<0.001 except HbA1c .

Table no2: Records the Percent Change in Lipids profile after treatment given. (10)

	Atorvastatin 40 mg (before)	Atorvastatin 40 mg (After)	Percentage Change	P value
Lipids, mg/dL				
Total Cholesterol (TC)	224.3±30.8	150.7±22.2	-32.81%	<0.001
LDL-C	158.3±22.6	83.9±15.1	-46.99%	<0.001
HDL-C	37.5±2.70	38.8±3.5	+3.46%	0.003
Triglyceride	165.8±30.8	141.4±22.6	-14.71%	<0.001
Non-HDL-C	180.6±31.2	113.2±18.1	-37.32%	<0.001
Glucose and HbA1C				
FBG, mg/dL	142.5±25.7	90.95±7.9	-36.17%	<0.001
HbA1c, %	5.82±0.2	5.71±0.3	-1.89%	0.198



DOI: 10.48175/IJARSCT-18789

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Table 3: Shows Percent Change in Lipids,(mg/dL) on a regular dose of Rosuvastatin 20mg for 6weeks. Total Cholesterol (TC)level reduced by(-26.49%), Low-density lipoproteins cholesterol(LDL-C) went down by (-37.28%), Triglyceride reduced to(-17.3%), Non-HDL-C went down by(-29.71%),after 6 weeks of medication. While there had been a reduction in the undesirable Lipids due to the above medication ,there was a positive upwards change in the desirable Lipids like high-density lipoprotein cholesterol (HDL-C) which improved by (+8.17%), Further, Fasting blood glucose, FBG, mg/dL level were reduced by (-37.95%). and HbA1c, % hemoglobin A1C test which measures blood sugar control over the preceding three months had also gone down by(-11.00%). The desirable alterations in respect of all the above parameters which were attributable to the above medication, were statistically significant, P<0.001---0.033.

Table no 3 : Shows Percent Change in Lipids,(mg/dL) on a regular dose of Rosuvastatin 20mg for 6 weeks**.** (10)

	Rosuvastatin 20 mg (before)	Rosuvastatin 20mg (After)	Percentage Change	P value
Lipids, mg/dL				
Total Cholesterol (TC)	226.1±35.4	166.2±25.7	-26.49%	<0.001
LDL-C	156.1±27.8	97.9±14.7	-37.28%	<0.001
HDL-C	35.5±2.21	38.4±3.6	+8.17%	<0.001
Triglyceride	164.6±28.2	136.2±23.4	-17.3%	<0.001
Non-HDL-C	182.4±29.2	128.2±20.5	-29.71%	<0.001
Glucose and HbA1C				
FBG, mg/dL	148.2±26.9	91.95±8.8	-37.95%	<0.001
HbA1c, %	5.62±0.4	5.5±0.2	-2.13%	0.187

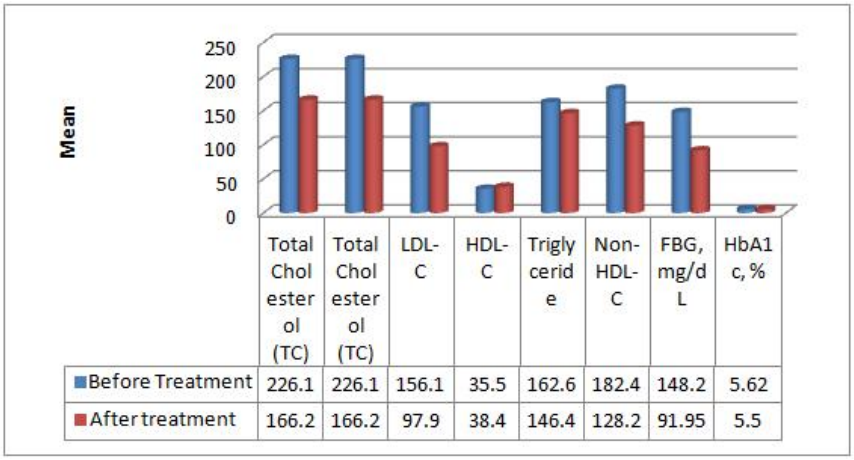

Table no4 Shows Percent Change in Lipids,(mg/dL) on a dose of Rosuvastatin 20mg on alternate Days for 6weeks. Total Cholesterol (TC)level reduced by(-26.36%), Low-density lipoproteins cholesterol (LDL-C) went down by (-37.53%), Triglyceride reduced by by(-11.63%), Non-HDL-C went down by(-29.71%),. While there had been a reduction in the undesirable Lipids due to the above medication ,there was a positive upwards change in the desirable Lipids like high-density lipoprotein cholesterol (HDL-C) which improved by(+8.17%), Further, Fasting blood glucose, FBG, mg/dL level were reduced by (-36.65%). and HbA1c, % hemoglobin A1C test which measures blood sugar control over the preceding three months had also gone down by(+4.07%). The desirable changes in respect of all the above parameters attributable to the above medication, were statistically highly significant, P<0.001---0.033 except HbA1c.

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	Rosuvastatin 20 mg alternate day (before)	Rosuvastatin 20 mg alternate day (After)	Percentage Change	P value
Lipids, mg/dL				
Total Cholesterol (TC)	225.3±40.7	165.9±23.1	-26.36%	<0.001
LDL-C	157.2±26.7	98.2±16.3	-37.53%	<0.001
HDL-C	36.4±1.90	38.5±2.9	+5.76%	< 0.001
Triglyceride	166.8±35.7	140.4±21.9	-15.83%	<0.001
Non-HDL-C	185.2±32.4	127.2±19.9	-31.31%	<0.001
Glucose and HbA1C				
FBG, mg/dL	145.8±27.4	92.35±9.6	-36.65%	<0.001
HbA1c, %	5.65±0.3	5.66±0.4	+0.17%	0.287

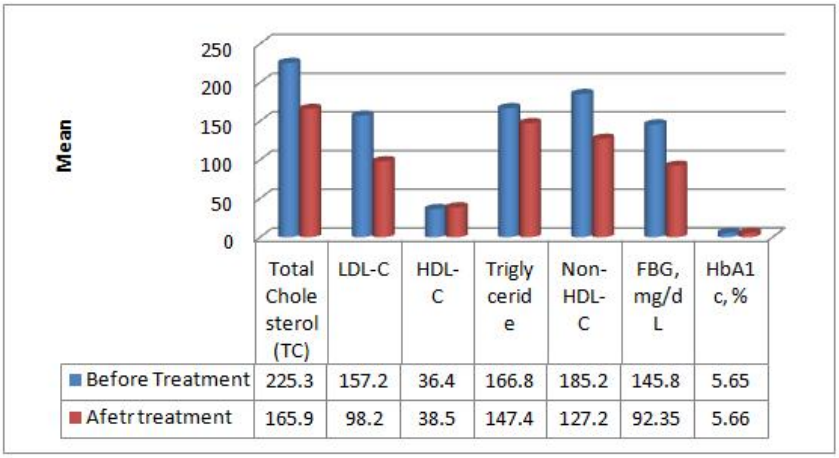

Table no 5 Shows metabolic parameters of patients of each of the three groups after 6 weeks of treatment. Metabolic parameters of patients of the three groups after 6 weeks of medication reveal that not only maximum quantities of harmful lipids like total cholesterol, LDL-C, Triglyceride, Non-HDL-C, Glucose, mg/dL ,have gone down, there was an increase in the useful lipids like HDL-C and in the patients treated with a regular dose of Atorvastatin 40 mg. In that group of patients the HbA1c, % level was also well within the normal range of4% to 5.6%. The variation in the quantities of Total Cholesterol , LDL-Cand HbA1c, % among the patients of the three groups was statistically significant as P<0.001. (10)

Table no 5 : Shows metabolic parameters of patients of each of the three groups after 6 weeks of treatment. (10)

	Atorvastatin 40 mg	Rosuvastatin 20mg	Rosuvastatin 20 mg alternate day	P value (I to II)	P value (I to III)	P value (II to III)
Lipids, mg/dL						
Total Cholesterol	150.7±22.2	166.2±25.7	165.9±23.1	<0.001	<0.001	0.9309
LDL-C	83.9±15.1	97.9±14.7	98.2±16.3	< 0.001	< 0.001	0.8914
HDL-C	38.8±3.5	38.4±3.6	38.5±2.9	0.4266	0.5100	0.8290
Triglyceride	141.4±22.6	146.4±23.4	147.4±21.9	0.1259	0.0580	0.7554
Non-HDL-C	113.2±18.1	128.2±20.5	127.2±19.9	< 0.001	< 0.001	0.7267
Glucose and HbA1C						
Glucose, mg/dL	90.95±7.9	91.95±8.8	92.35±9.6	0.398	0.261	0.759
HbA1c, %	5.71±0.3	5.5±0.2	5.66±0.4	0.013	0.010	0.056

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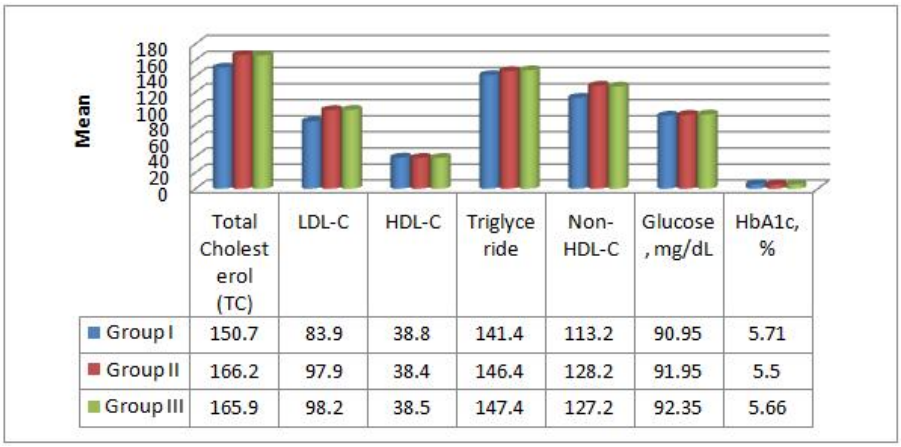
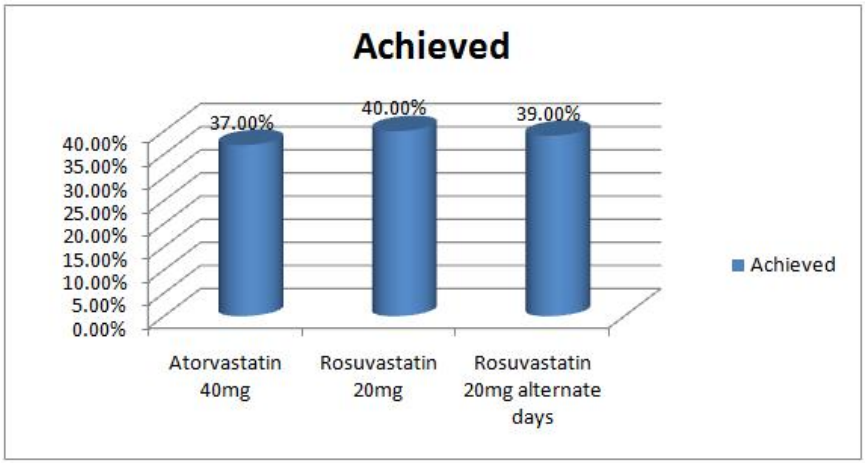


	Total Cholesterol (TC)	LDL-C	HDL-C	Triglyceride	Non-HDL-C	Glucose, mg/dL	HbA1c, %
Group I	150.7	83.9	38.8	141.4	113.2	90.95	5.71
Group II	166.2	97.9	38.4	146.4	128.2	91.95	5.5
Group III	165.9	98.2	38.5	147.4	127.2	92.35	5.66

Table no 6 *National Cholesterol Education Program* NCEP ATP III goal. Figures show that while NCEP ATP III goal was achieved by40 (40%) patient treated with a regular dose of Rosuvastatin 20mg, 39 (39%)patient could achieve the goal with an alternate dose of Rosuvastatin 20mg . As for treatment with Atorvastatin 40mgwas concerned only 37 (37%) patient achieved the goal as stipulated by *National Cholesterol Education Program* NCEP ATP III goal. (10)

Table no 6 (10 Bold) **:** National Cholesterol Education Program NCEP ATP III goal**.** (10)

Number of patients (%) achieving NCEP ATP III goal		
Statin therapy	Achieved (%)	Total
Atorvastatin 40mg	37 (37)	100
Rosuvastatin 20mg	40 (40)	100
Rosuvastatin 20mg alternate days	39 (39)	100
Total	116(38.66)	300



V. DISCUSSION

Dyslipidemia in patients with diabetes plays an important role in development of atherogenesis. The standarded of treatment for dyslipidemia have been statins.For the treatment of dyslipidemia the most commonly used statins are are atorvastatin and rosuvastatin. (10)

The four major statin beneficiary groups have already been defined by NCEP 2013 report.

There is a wealth of evidence suggesting that lowering low density lipoprotein cholesterol (LDL-C) reduces the risk of cardiovascular disease (CVD). Both European and US guidelines for CVD prevention recommend the use statins as first-line therapy for dyslipidemia and specify target LDL-C levels. Previously, a National Cholesterol Education

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.53
Volume 4, Issue 1, June 2024

Program (NCEP) report had proposed to lower target levels to even more aggressive LDL-C goals for very high-risk patients.

Despite the proven benefits of LDL-C reduction ,lipid managenent is suboptimal and many patients fail to achieve recommended LDL-C goals[11,12].Themost likely reasons for this are the use of agents with poor efficacy for LDL-C lowering and suboptimal dose titration.

Such aggressive LDL-C goals,however are harder to achieve. The most effective statin at the lowest dose would represent a simple, effective treatment strategy, enabling more patients to achieve goals without the need for dose titration.

Rosuvastatin, at a dose of 20 mg, has demonstrated high efficacy for LDL-C lowering, enabling patients with hypercholesterolemia to achieve their lipid goals[10,11].

Currently no Indian study is available for treating diabetic patients with dyslipidemia or dyslipidemia alone with statin on alternate day and no previous study has documented the efficacy, safety and cost effectiveness of various statins prescribed to diabetic patients. Thus the present study aimed to build on this growing awareness of atherosclerosis-specific care of diabetes patients, by examining efficacy and safety of the two most commonly prescribed statins in India.

The present study was an open label prospective comparative study done in Department of General Medicine, at Dr. Ram Manohar Lohia Combined Hospital a tertiary care teaching hospital,Lucknow, Uttar Pradesh in the time interval of November 2014 to November 2015.. (10)

The study, shows that rosuvastatin (20mg daily and 20 mg on alternarnate days) was found to be the most effective statin at reducing LDL-C when compared with atorvastatin (40 mg) daily. In other words, rosuvastatin at its lowest dose in this study (20 mg) on alternate days was more effective at reducing LDL-C levels than atorvastatin at their higher dose (40 mg) daily. Our results are consistent with STELLAR trial which is one of the major open-label, randomized, and multicenter trials to compare rosuvastatin (10, 20, 40, or 80 mg) with atorvastatin (10, 20, 40, or 80 mg), pravastatin (10, 20, or 40 mg), and simvastatin (10, 20, 40, or 80 mg) across dose ranges for reduction of LDL-C[13]. The results of the STELLAR trial revealed that rosuvastatin was consistently, across all doses, the most effective at reducing LDL-C levels in comparison to all of the other statins. (10)

Brunzell JD et al reported the lowering of triglycerides is another important goal in reducing CVD risk among diabetic patients.[5] In the present study, the greatest reduction in triglycerides was (−17.3%, $P < 0.01$) and was achieved by patients taking rosuvastatin (20 mg daily). This was the case, even in comparison with rosuvastatin 20 mg on alternate days and to higher doses of atorvastatin (40 mg). However, it is important to note that rosuvastatin (20 mg on alternate day) and atorvastatin (40 mg) both achieved the second highest reduction in triglycerides (−15.83%, $P < 0.05$, and −14.71%, $P<0.05$), respectively. These findings are similar to the majority of studies in the literature, which have shown a slightly higher reduction in triglycerides in patients taking rosuvastatin in comparison to atorvastatin as reported by Clearfield MB et al.[14]. It thus appears that, reduction in triglyceride levels is equal with rozuvastatin and atorvastatin in relation to this factor (triglycerides), and that both rosuvastatin and atorvastatin are effective in reducing it.

Raising HDL-C levels is another major factor known to reduce CVD risk. In the present study, all of the statins were found to increase HDL-C levels as has been shown in previous studies. Rosuvastatin (20 mg daily) lead to maximal increase (+8.17%). (10)

VI. CONCLUSION

Rosuvastatin 20 mg on every other regimen had equal effect when compared to daily dose regimen of atorvastatin 40 mg &rosuvastatin 20mg

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IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
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