IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)
e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 17, Issue 2 Ver. 11 February. (2018), PP 24-31
www.iosrjournals.org

The Relationship between Vitamin D Level and Macrovascular And Microvascular Complications In Type 2 Diabetes Mellitus

Kumar M[1], Kapuriya S[2], Agrawal Rp[3], Meel Jk[4], Sirohi P[5], Chahar K[6], Gadhwal A[7], Ankit Bs[7], Phogawat M[1], Gupta Rk[1]
Department of Medicine & Pathology, S.P. Medical College, Bikaner
Corresponding Author: Kumar M

Abstract
Background *: The role of Vitamin D deficiency in microvascular complications has been documented. However the effect of vitamin D deficiency on macrovascular complications are not studied extensively. Hence this study evaluate the effect of vitamin D deficiency on both microvascular and macrovascular complications in type 2 diabetes mellitus.*
Material and Methods *: The study was conducted on 200 patients with type 2 diabetes mellitus in which 100 patients are having vascular complications of diabetes(group 1) and 100 patients without vascular complications(group 2). To compare the level of vitamin D, 100 age-sex matched controls without diabetes (group 3) are taken. 25(OH) vitamin D level was measured among all three groups from the serum by ELISA kit. All vascular complications are measured by standard techniques used worldwide.*
Results *: The mean level of vitamin D in group 1 and group 2 and group 3 were 7.53±2.14 and 11.23±3.44 and 31.48±6.43 ng/ml respectively. The 25(OH) vitamin D deficient subjects in group 1 and group 2 and group 3 were 79(79%) and 56(56%) and 14(14%) respectively. The microvascular complications of diabetes mellitus are higher in vitamin D deficiency with vitamin D levels less than 30 ng/ml (P<0.05). The macrovascular complications of diabetes mellitus are also higher in vitamin D deficiency with vitamin D levels less than 30 ng/ml (P<0.05). The number of vascular complications are significantly correlated with vitamin D deficiency severity (p=0.0001)*
Conclusion : *The study gives us an insight to identify the diabetics with vitamin D deficiency which may be at higher risk of vascular complications. Vitamin D deficiency is higher among patients with type 2 diabetes mellitus as compared to controls. Vitamin D deficiency is also higher in patients with type 2 diabetes with vascular complications. Vitamin D deficiency is also associated with severity of vascular complications in type 2 diabetes Further, a need to undertake future prospective multicenter study with larger number of subjects to find a cause effect relationship between vitamin D deficiency and vascular complications in patients of type 2 diabetes mellitus is required. This may help us to initiate interventional studies to see the reversal effect with supplementation of vitamin D to halt the progression of vascular complications and atherosclerosis in patients of type 2 DM.*

1. *Senior Registrar*
2. *Junior Registrar, Department of Pathology*
3. *Principal & Controller, Sr. Professor*
4. *Medical Officer*
5. *Professor*
6. *Assistant Professor*
7. *Senior Resident*

Date of Submission: 08-02-2018 Date of acceptance: 23-02-2018

I. Introduction

Vitamin D deficiency has been associated with increased risk of macrovascular and microvascular disease events in type 2 diabetes, including higher risk of acute myocardial infarction (AMI), cardiovascular deaths, stroke, nephropathy, peripheral vascular diseases, retinopathy and neuropathy[1].

Recent reports have suggested associations between vascular disease, diabetes and vitamin D deficiency[2-7]. The Fenofibrate intervention and event lowering in diabetes (FIELD) study provides a unique opportunity to examine the relationship of blood vitamin D concentration with macrovascular and microvascular events[8-10]. Higher rates of cardiovascular disease with lower vitamin D levels have also been reported.

Potential mechanisms that explain the relationship between vitamin D deficiency and vascular disease (microvascular and macrovascular disease) include pancreatic beta cell dysfunction, peripheral insulin

resistance, chronic inflammation and endothelial dysfunction. In animal models, vitamin D deficiency impairs insulin synthesis[11,12], possibly via a reduced intracellular calcium concentration[13].

Macroangiopathy in diabetes consists mainly of an accelerated form of atherosclerosis and affects the coronary, carotid and peripheral arteries, thus increasing the risk of myocardial infarction, stroke and diabetic foot disease[14-17]. The increase in cardiovascular risk with aging is attributable in large part to vascular endothelial dysfunction. Insulin signaling is impaired in states of insulin resistance such as in type 2 diabetes, resulting in a marked decrease in NO bioavailability, and increased vascular inflammation, including enhanced expression of interleukin (IL) 6, vascular cell adhesion molecule 1 (VCAM-1), and monocyte chemoattractant protein 1 (MCP-1). Moreover, hyperglycemia leads to increased formation of advanced glycation end products (AGE), which quench NO and impair endothelial function[18].

Microangiopathy in type 2 diabetes occurs by polyol pathway involves the conversion of glucose into glucose alcohol (sorbitol). High glucose levels increase the flux of sugar molecules through the polyol pathway, which causes sorbitol accumulation in cells. Osmotic stress from sorbitol accumulation has been postulated as an underlying mechanism in the development of diabetic microvascular complications. Other factors are nonenzymatic glycation of proteins, oxidative stress, activation of protein kinase C production, decrease of vasodilatation products (nitric oxide, prostaglandines), decrease of myoinositol origin, change in Na+K+ATP-ase activity causing the endothelial damage. Growth factors, including vascular endothelial growth factor (VEGF), growth hormone, and transforming growth factor β, have also been postulated to play important roles in the development of diabetic retinopathy[19].

Vitamin D deficiency may be responsible for endothelial dysfunction which in turn affects the onset and progression of vascular disease and its risk factor, directly or indirectly through various mechanisms. There are few potential biological mechanisms that might be postulated for the protective effects of vitamin D against atherosclerosis. Vitamin D can inhibit various aspects of inflammation, which has been established as a key pathological mechanism in atherosclerosis. It can exert an anti-proliferative effect on vascular smooth muscle cells and myocardial hypertrophy and proliferation, which underlies the pathogenesis of congestive heart failure. It can also improve insulin secretion and resistance which is thought to play a casual role in atherosclerosis. It can act as a negative endocrine regulator of renin angiotensin system which itself plays an important role in hypertension and cardiovascular death.

Aims & Objectives

1. To compare the levels of vitamin D among patients of type 2 diabetes mellitus with age-sex matched controls.
2. To study the prevalence of macrovascular and microvascular complications in patients with type 2 diabetes mellitus with vitamin D deficiency.
3. To study the cause effect relationship of vitamin D with macrovascular and microvascular complications in patients with type 2 diabetes mellitus.

II. Material & Methods

Subject selection

200 cases of type 2 diabetes mellitus(100 cases with vascular complications and 100 cases without complications) aged 40-60 years attending diabetic care research Centre were taken as per WHO criteria. 100 cases without type 2 diabetes mellitus matched for confounding factors were taken as controls.

Clinical Protocol

All the patients fulfilling criteria for cases and controls attending diabetic clinic went through detailed history and clinical examination. Participants were asked to provide information about their age, marital status, occupation, educational attainment, medical history, smoking, alcohol consumption, and participation in regular physical exercise. The data was collected on a specially designed proforma having baseline demography and participants went through detailed physical and laboratory testing. Venous blood samples were collected for the investigations including vitamin D levels within 24 hours of admission after overnight fasting than Participants were subjected to test for vascular complications.

Routine investigations

- Hb, TLC, DLC, ESR
- Blood urea, serum creatinine
- Blood sugar (fasting and postprandial), oral glucose tolerance test, HbA_1C
- Serum electrolytes
- Liver function test
- Lipid profile

- Urine routine and microscopy
- ECG
- Fundus examination

Vitamin D levels

Approximately 3 ml of venous blood sample was withdrawn in a plain vial after an overnight fast. Samples were stored at 2-8^{0}c for maximum three days.

25(OH) vitamin D level was measured from the serum by commercially available 25-OH vitamin D (total) ELISA kit (EIA 5396, DRG instruments GmbH, Germany).

Principle of assay

The DRG 25-OH vitamin D total ELISA kit was a solid phase ELISA based on the principle of competitive binding. In the first step, samples were pretreated in separate vials with denaturation buffer to extract the anylate, since most circulating 25-OH vitamin D is bound to vitamin D binding protein. After neutralization, biotinylated 25-OH vitamin D (enzyme conjugate) and peroxidase-labeled streptavidin (enzyme complex) were added. After careful mixing, the solution was transferred to the microtiter plate. Endogenous 25-OH vitamin D of a patient sample competes with a 25-OH vitamin D-biotin conjugate for binding to the vitamin D binding protein (VDBG) that was immobilized on the plate. Binding of 25-OH vitamin D was detected by peroxidase-labeled streptavidin. Incubation was followed by a washing step to remove unbound components. The color reaction was started by addition of enzyme substrate and stopped after a defined time. The color intensity was inversely proportional to the concentration of 25-OH vitamin D in the sample.

Assessment Of Microvascular And Macro-Vascular Complications

1. Diabetic retinopathy:- Tested by ophthalmoscopic fundus examination : After dilation of pupil by 0.5% and 1% tropicamide eye drops. In diabetics several abnormalities in retina like microaneurysms, haemorrhages, macular edema, exudates and cotton-wool spots are found.
2. Diabetic nephropathy:-Incipient nephropathy is tested by micralbuminuria test. Incipient nephropathy is presumed to be present if any two readings out of three of 24 hours urinary albumin were ranging from 30 to 300mg/24hr (microalbuminuria). Overt nephropathy is tested by elevated levels of serum creatinine and blood urea or presence of macroalbuminuria.
3. Diabetic neuropathy:- Diagnosed by history of neuropathic symptoms like numbness, paraesthesias, tingling sensation, burning sensation and comprehensive foot exam and confirmed the touch sensation by using the 10 gm semmes weinstein monofilament at four sites on each foot, vibration sense by biothesiometer (Vibration perception threshold at great toe >25 is considered significant) and ankle reflexes.
4. Peripheral vascular diseases:-Diagnosed by history of intermittent claudication, examination of Peripheral pulses and measurement of ankle brachial index by Doppler study. Ankle systolic pressure measured of dorsalis pedis and posterior tibial artery and brachial systolic pressure measured of brachial artery by doppler ultrasound device. Ankle brachial index less than 0.9 is considered significant.
5. Coronary artery disease:-Diagnosed by history of angina or myocardial infarction, electrocardiographic findings of myocardial infarction according to Minnesota code classification system and chest x-ray to assess cardiac size.
6. Stroke:-Diagnosed by history and examination of nervous system. Stroke is considered when patient presenting with an acute neurological deficit(focal or global) and common signs and symptoms of stroke like hemiparesis, monoparesis, hemisensory deficits, monocular or binocular visual loss, visual field defects, diplopia, dysarthria, aphasia, ataxia and sudden decrease in the level of consciousness are present.

Statistical analysis

Statistical analysis was done using SPSS 22.0. Descriptive analysis was done with help of frequencies, mean +/- S.D. Inferential statistics used were chi square test, linear regression and correlation, logistic regression, odds ratio and ANOVA keeping 95% confidence interval. P value less than 0.05 was considered to be significant.

III. Results

The mean level of vitamin D in group 1 and group 2 and group 3 were 7.53±2.14 and 11.23±3.44 and 31.48±6.43 ng/ml respectively (Table 1, figure 1). The vitamin D levels were lower in group 1 as compared to group 2 and group 3 with the difference being statistically significant ($p<0.0193$).

Subjects were divided into 3 subgroups according to the severity of vitamin D deficient state as per the following levels:

1. 25(OH) vitamin D <20 ng/ml - Vitamin D deficient
2. 25(OH) vitamin D 20-30 ng/ml - Vitamin D insufficient
3. 25(OH) vitamin D >30 ng/ml - normal range

The 25(OH) vitamin D deficient subjects in group 1 and group 2 and group 3 were 79(79%) and 56(56%) and 14(14%) respectively. The 25(OH) vitamin D insufficient subjects in group 1 and group 2 and group 3 were 12(12%) and 22(22%) and 7(7%) respectively. However, only 9% of subjects in group 1 and 22% in group 2 had vitamin D in normal range. Subjects with vitamin D deficient and insufficient state were far greater in group 1 than group 2 and group 3. Further, the number of subjects with normal vitamin D levels was much lower in patients of type 2 diabetes. Overall, considering all the subjects, 49.66% of subjects were vitamin D deficient, 13.66% were vitamin D insufficient and only 36.66% had vitamin D in normal range [table 1 and figure 1].

The microvascular complications of diabetes mellitus are higher in vitamin D deficiency with vitamin D levels less than 30 ng/ml. Neuropathy was found in 76.92% patients in vitamin D deficient state and in only 11.11% in vitamin D sufficient state and the difference being statistically significant ($p < 0.037$). Nephropathy was found in 35.16% patients in vitamin D deficient state and nephropathy was absent in vitamin D sufficient state and the difference being statistically significant ($p < 0.041$). Retinopathy was found in 85.71% patients of vitamin D deficiency and retinopathy was absent in vitamin D sufficient state and the difference being statistically significant ($p<0.018$). The macrovascular complications of diabetes mellitus are also higher in vitamin D deficiency with vitamin D levels less than 30 ng/ml. Coronary artery disease(CAD) was found in 31.86% patients in vitamin D deficient state and CAD was absent in vitamin D sufficient state with the difference being statistically significant ($p<0.039$). Peripheral artery disease (PAD) was found in 23.07% patients in vitamin D deficient state and PAD was absent in vitamin D sufficient state with the difference being statistically significant ($p<0.041$). Stroke was found in 18.68% patients in vitamin D deficient state and stroke was absent in vitamin D sufficient state with the difference being statistically significant ($p<0.047$) (Table 2).

Above table shows that patients with no complications had higher serum vitamin D levels as compared to that of patients with one or the other complications. As number of complications in study population increased, decrease in serum vitamin D levels was observed. Also, the mean vitamin D levels were observed to be statistically significant among patients without complications and with complications ($p=0.0001$).

The mean value of vitamin D if only single vascular complication (N=53) present is 11.4±2.83 and mean value of vitamin D if two vascular complications (N=27) present is 10.74±4.17 and mean value of vitamin D if three vascular complications (N=10) present is 9.87±5.10 and mean value of vitamin D if four vascular complications (N=4) present is 8.7±2.69 and mean value of vitamin D if five vascular complications (N=5) present is 7.17±1.67 and mean value of vitamin D if six vascular complications (N=1) present is 7.3±0. So quantity of vascular complications is also associated with severity of vitamin D deficiency and association being statistically significant ($p<0.0001$) (Table 3, figure 2).

While applying logistic regression on all independent factors associated with occurrence of complications, along with HbA1C ($p=0.002$) and Vitamin D ($p=0.0193$); duration of disease ($p=0.049$) was also observed to be significantly associated with occurrence of vascular complications in diabetes mellitus (Table 4, Figure 3).

Association

In this study, a negative association was found between vascular complications and 25(OH) vitamin D levels in diabetes mellitus. The 95% confidence interval between any vascular complication and 25(OH) vitamin D was also found to be -0.035 - -0.007 (table 3).

While applying logistic regression on all independent factors associated with occurrence of complications, along with HbA1C ($p=0.002$) and Vitamin D ($p=0.0193$); duration of disease ($p=0.049$) was also observed to be significantly associated with occurrence of vascular complications in diabetes mellitus (Table 13, Figure 8).

Association

In this study, a negative association was found between vascular complications and 25(OH) vitamin D levels in diabetes mellitus. The 95% confidence interval between any vascular complication and 25(OH) vitamin D was also found to be -0.035 - -0.007 (table 11). Further, on analysis of association between vascular complications by logistic regression and vitamin D in cases, the confidence interval was 0.8094 - 0.9815 positive (Table 12). On analyzing the association between microvascular and macrovascular complications and 25(OH) vitamin D, it was observed that vascular complications has a direct negative association to vitamin D deficiency.While studying the association between serum vitamin D levels and individual vascular complications it was revealed that association was much stronger in patients with type 2 diabetes. Similar

pattern of association was evident in between serum vitamin D level and combined vascular complications in patient of type 2 DM.

On further analysis of data it was found that vascular complications was correlated with different parameters studied. The value of vascular complications increases with increasing diabetes duration, increasing HbA1c and decreasing vitamin D level.

IV. Conclusion

The present case control and cross-sectional study was carried among patients of type 2 diabetes mellitus, which revealed vitamin D deficiency state is higher among cases of type 2 DM with vascular complications. In the most of the subjects (cases and controls) the 25(OH) vitamin D levels were lower than normal. Microvascular and macrovascular complications was found to be higher among the patients of type 2 DM with vitamin D deficiency. Microvascular and macrovascular complications was much lower in subgroups of subjects having vitamin D sufficiency state. Vascular complications had a negative correlation with 25(OH) vitamin D level in patients of type 2 DM.

The study gives us an insight to identify the diabetics with vitamin D deficiency which may be at higher risk of vascular complications. Further, a need to undertake future prospective multicenter study with larger number of subjects from Indian population to find a cause effect relationship between vitamin D deficiency and vascular complications in patients of type 2 diabetes mellitus is required. This may help us to initiate interventional studies to see the reversal effect with supplementation of vitamin D to halt the progression of vascular complications and atherosclerosis in patients of type 2 DM.

References

[1]. Herrmann M, Sullivan DR, Veillard AS, McCorquodale T, Straub IR, Scott R et al. Serum 25-Hydroxyvitamin D : A predictor of macrovascular and microvascular complications in patients with type 2 diabetes. Diabetes care 2015; 38:521-528.

[2]. Giovannucci E, Liu Y, Hollis BW, Rimm B. 25-Hydroxyvitamin D and risk of myocardial infarction in men: a prospective study. Arch intern med 2008; 168:1174-1180.

[3]. Ginde AA, Scragg R, Schwartz RS, Camargo CA Jr. Prospective study of serum 25-Hydroxyvitamin D level, cardiovascular disease mortality, and all-cause mortality in older U.S. adults. J Am Geriatr Soc 2009; 57:1595-1603.

[4]. Scragg R. Vitamin D and cardiovascular disease: a review of the epidemiological and clinical evidence. In : Vitamins in the prevention of the human diseases. Herrmann W, Obeid R, Eds, Berlin, De Gruyter, 2011; pp409-426.

[5]. Pittas AG, Lau J, Hu FB, Dawson-Hughes B. The role of vitamin D and calcium in type 2 diabetes. A systemic review and meta-analysis. J Clin Endocrinol Metab 2007; 92:2017-2029.

[6]. Palomer X, Gonzalez-Clemente JM, Blanco-Vaca F, Mauricio D. Role of vitamin D in the pathogenesis of type 2 diabetes mellitus. Diabetes Obes Metab 2008; 10:185-197.

[7]. Takiishi T, Gysemans C, Bouillon R, Mathieu C. Vitamin D and diabetes. Endocrinol Metab Clin North Am 2010; 39:419-446.

[8]. Keech AC, Mitchell P, Summanen PA, O'Day J, Davis TM, Moffitt MS et al. FIELD study investigators. Effects of fenofibrate on the need for laser treatment for diabetic retinopathy (FIELD) study: a randomized controlled trial. Lancet 2007; 370:1687-1697.

[9]. Keech A, Simes RJ, Barter P, Best J, Scott R, Taskinen MR et al. FIELD study investigators. Effects of long term fenofibrate therapy on cardiovascular events in 9795 people with type 2 diabetes mellitus (the FIELD study): randomized controlled trial. Lancet 2005; 366:1849-1861.

[10]. Davis TM, Ting R, Best JD, Donoghoe MW, Drury PL, Sullivan DR et al. Fenofibrate Intervention and Event Lowering in diabetes study investigators. Effects of fenofibrate on renal function in patients with type 2 diabetes mellitus: the Fenofibrate Intervention and Event Lowering in Diabetes (FIELD) study. Diabetologia 2011; 54:280-290.

[11]. Norman AW, Frankel JB, Heldt AM, Grodsky GM. Vitamin D deficiency inhibits pancreatic secretion of insulin. Science 1980; 209:823–825.

[12]. Cade C, Norman AW. Vitamin D3 improves impaired glucose tolerance and insulin secretion in the vitamin D-deficient rat in vivo. Endocrinology 1986; 119:84–90.

[13]. Billaudel BJ, Faure AG, Sutter BC. Effect of 1,25 dihydroxyvitamin D3 on isolated islets from vitamin D3-deprived rats. Am J Physiol 1990; 258:E643–E648.

[14]. Duby JJ, Campbell RK, Setter SM, White JR, Rasmussen KA. Diabetic neuropathy: an intensive review. Am J Health Syst Pharm 2004; 61:160–173.

[15]. Goldberg RB. Cardiovascular disease in patients who have diabetes. Cardiol Clin 2003; 21:399–413.

[16]. Porta M, Bandello F. Diabetic retinopathy: a clinical update. Diabetologia 2002; 45:1617–1634.

[17]. Kikkawa R, Koya D, Haneda M. Progression of diabetic nephropathy. Am J Kidney Dis 2003; 41:S19–S21.

[18]. Hartge MM, Kintscher U, Unger T. Endothelial Dysfunction and Its Role in Diabetic Vascular Disease. Endocrinol Metab Clin N Am 2006; 35:551–560.

[19]. ADA Clinical Diabetes 2008; 26(2):77-82.

Table 1

Comparison of vitamin D levels in group 1 and group 2 and group 3

VIT D LEVELS (ng/ml)	T2DM with Complications		T2DM without Complications		Healthy	
	No.	%	No.	%	No.	%
>30	9	9.0	22	24.0	79	79.0
21-30	12	12.0	22	20.0	7	7.0
15-20	15	15.0	28	28.0	6	6.0
10-14	30	30.0	20	20.0	6	6.0
<10	34	34.0	8	8.0	2	2.0

Total	100	100.0	100	100.0	100	100.0
Mean±SD	7.53±2.14		11.23±3.44		31.48±6.43	

Table 2

Association Of Complications Occurrence With Vitamin D Levels Below Or Above The 30 Ng/Ml Threshold

S.NO.	Complications	Present (N=100)		Absent (N=100)		P Value
		No.	%	No.	%	
A.	**MICROVASCULAR**					
1.	Neuropathy: -VIT D <30 ng/ml - VIT D >30 ng/ml	 70/91 1/9	 76.92 11.11	 78 22	 78.0 22.0	0.037
2.	Nephropathy: -VIT D <30 ng/ml - VIT D >30 ng/ml	 32/91 0/9	 35.16 0.0	 78 22	 78.0 22.0	0.041
3.	Retinopathy: -VIT D <30 ng/ml - VIT D >30 ng/ml	 78/91 0/9	 85.71 0.0	 78 22	 78.0 22.0	0.018
B.	**MACROVASCULAR**					
4.	Peripheral Arterial disease: - VIT D <30 ng/ml - VIT D >30 ng/ml	 21/91 0/9	 23.07 0.0	 78 22	 78.0 22.0	0.041
5.	Coronary artery Disease: - VIT D <30 ng/ml - VIT D >30 ng/ml	 29/91 0/9	 31.86 0.0	 78 22	 78.0 22.0	0.039
6.	Stroke: - VIT D <30 ng/ml - VIT D >30 ng/ml	 17/91 0/9	 18.68 0.0	 78 22	 78.0 22.0	0.047

Table 3

Association of concurrent occurrence of Complications with Serum Vitamin D levels

No. of complications	Vitamin D Levels		
	Mean	SD	
0 complications (N1=100)	11.23	3.44	P= 0.0001
1 complications (N2=53)	11.04	2.83	
2 complications (N3=27)	10.74	4.17	
3 complications (N4=10)	9.87	5.10	
4 complications (N5=4)	8.7	2.69	
5 complications (N6=5)	7.17	1.67	
6 complications (N7=1)	7.3	0	

Table-4

Logistic regression to study each independent risk factor's contribution towards occurrence of complications among T2DM patients

Independent Variable	**Odds Ratio**	**95%C.I.**	**Z-Statistic**	**P-Value**
Age	0.672	0.9884-1.3772	-0.0372	0.9703
BMI	1.0367	0.8352 - 1.2868	0.3266	0.7439
Duration	**1.684**	**1.153- 3.348**	**2.6374**	**0.0492**
FBS	0.9717	0.9294 - 0.016	-1.2608	0.2074
HbA1C	**3.6403**	**1.5606 - 8.4917**	**2.9898**	**0.0028**
Onset of DM	0.8684	0.6518-1.8613	0.037	0.9705
PPBS	1.0192	0.9927-1.0425	1.4143	0.1573
Sex	0.9058	0.2514 - 3.2638	-0.1512	0.8798
VITAMIN D	**1.8913**	**0.8094 - 0.9815**	**-2.3389**	**0.0193**
W/H RATIO	1.6598	0.294 - 9.3695	0.5738	0.5661

Fig. 1 : Comparison of vitamin D levels in group 1 and group 2 and group 3

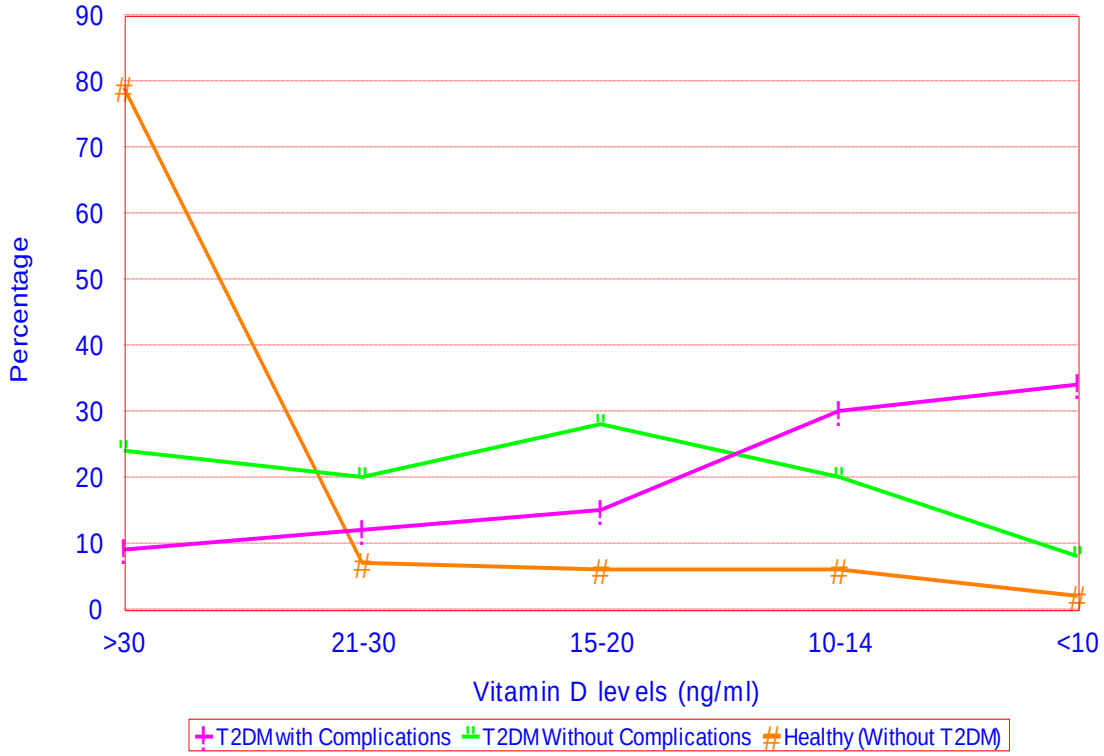


Fig. 2 : Association of concurrent occurrence of Complications with Serum Vitamin D levels

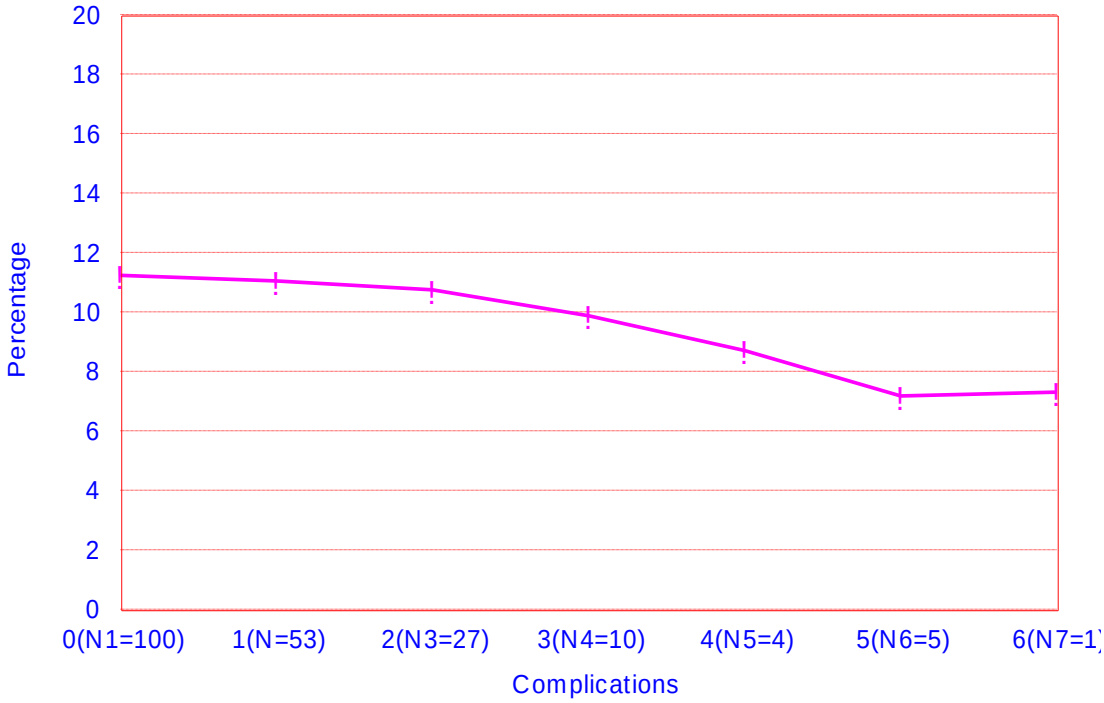
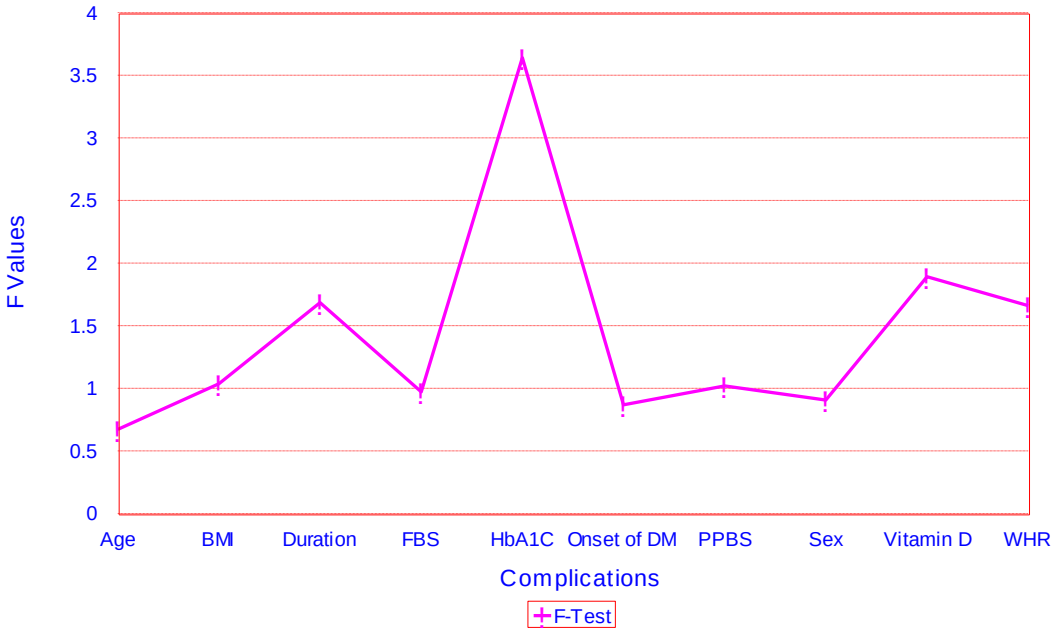


Fig. 3 : Logistic regression to study each independent risk factor's contribution tow ards occurrence of complications among T2DM patients



Kumar M The Relationship Between Vitamin D Level And Macrovascular And Microvascular Complications In Type 2 Diabetes Mellitus". "IOSR Journal of Dental and Medical Sciences (IOSR-JDMS), Volume 17, Issue 2 (2018), PP 24-31.