NON INVASIVE ASSESSMENT OF ENDOTHELIAL DYSFUNCTION IN ESSENTIAL HYPERTENTION WITH OR WITHOUT MICROALBUMINURIA

Arvind M.N[1], V. Channaraya[2]

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ABSTRACT: BACKGROUND: Endothelial dysfunction is an early event in atherosclerosis and is known to appear long before the formation of structural atherosclerotic changes. Assessment of endothelial function, thus, can provide valuable insight into pre-intrusive phase of atherosclerosis and can be used as an early marker of future atherosclerotic disease. Flow mediated dilation (FMD) is known to depend on ability of the endothelium to release NO in response to shear stress and can be used reliably as an estimate of endothelial function in various disease states.**AIMS OF THE STUDY:** To study endothelial dysfunction in patients with hypertension and compare with non-hypertensive subjects.To correlate the duration of hypertension with prevalence of endothelial dysfunction.To correlate microalbuminuria with endothelial dysfunction in essential hypertension.To correlate risk factors of atherosclerosis in essential hypertension with endothelial dysfunction. **METHODS:** Endothelial function was assessed non-invasively by high resolution Duplex Doppler Ultrasound of Brachial Artery in fifty cases of hypertensives with or without microalbuminuria and twenty controls who were healthy subjects. Brachial artery assessment was performed in both cases and control.**RESULTS:** In this study, it is observed that among 50 hypertensives, endothelial dysfunction was seen in 15 (30%), whereas none of control had endothelial dysfunction. The mean age for hypertensives who had endothelial dysfunction was (50.56) in males and (48.83) in females. Among the cases 9 (60%) of males and 6 (40%) of females had FMD < 4.5%. Among hypertensives 12 (24%) had microalbuminuria. Hypertensives with microalbuminuria having endothelial dysfunction were 4 (33.3%) and hypertensives without microalbuminuria and havingendothelial dysfunction were 8 (66.7%).**CONCLUSION:** In this study, of 50 hypertensives, endothelial dysfunction was present in 15 (30%) cases. Endothelial dysfunction was more common in males 9(60%) and females 6 (40%).The endothelial dysfunction is independent of Body mass index, High density lipoprotein, duration of hypertension and microalbuminuria but dependent on Triglycerides, Low density lipoprotein and Flow-mediated dilatation.

KEYWORDS: Angiotensin Converting Enzyme, Body Mass Index, Coronary Artery Disease, Cerebrovascular Accident, Endothelial Dysfunction, Flow Mediated Dilatation, Hypertension, Ischaemic Heart Disease, NitricOxide, Triglycerides, Urinary Albumin Excretion.

INTRODUCTION: Essential hypertension is the most common cardiovascular disorder.[1,2,3,4,5] It is associated with functional and morphological alterations of the endothelium.[6,7,8,9] Due to its position between blood stream and smooth muscle cells, the endothelium is thought to be both target and mediator of arterial hypertension.[7,10,11]

Endothelial dysfunction contributes to the underlying disease process of a number of conditions, including essential hypertension, hypercholesterolemia,[12,13.] atherosclerosis,[14] diabetes

mellitus, [12,15,16,17,18] congestive heart failure[14] and pulmonary hypertension. Over the last decade, extensive research has focused on determining not only the presence but also the nature of endothelial dysfunction in patients with conditions associated with premature development of atherosclerosis.[10,11,8,20]

A large proportion of non-diabetic patients with hypertension excrete albumin in the microalbuminuric range.[7,8] Increased urinary albumin excretion (UAE) is related to systemic disorders of transcapillary escape rate; and epidemiological studies have identified microalbuminuria as a risk factor for illness of athero-thrombotic origin. [7,8,21] Endothelial damage may initiate atherosclerosis since the endothelium is involved in permeability, fibrinolysis, haemostasis and blood pressure control.[6,7,8,21]

In support of this possibility haemodynamic studies exploring the renal response to the nitric oxide (NO) precursor L-arginine have consistently demonstrated an impaired renal vascular relaxation in hypertension subjects.[21,22,23,24,25,26] Such a hypothesis may also contribute to explain why both endothelial dysfunction and microalbuminuria are independent predictors of adverse cardiovascular outcomes in hypertensive patients.[19,20,27,28]

Brachial artery flow mediated vasodilatation(FMD) has been shown to correlate well with measures of coronary endothelial function in various studies, since the factors affecting the endothelial function influence all the vascular beds.[4,6,29,30] Development of non-invasive method of endothelial function assessment by brachial artery flow mediated vasodilatation (FMD), as described by CelaerMajer provided an extremely useful fool for cardiovascular research and for clinical application.[10,11] The test can be performed easily and has proven reproducibility. The international task force on brachial artery reactivity has recently laid guidelines for performance of FMD, thus standardizing the test for wider application.[11,29]

The earliest clinical evidence of nephropathy is the appearance of low but abnormal level of albumin in the urine, referred to as microalbuminuria.[31,32,33] Microalbuminuria is defined as an albumin excretion rate > 20 mcg/minute(or 20 mg/ 24 hours) and less than 200 mcg/minute.20[,34,35,36,37]

Thus, in this study we have tried to study endothelial dysfunction in essential hypertension using FMD and co-relating with microalbuminuria.

OBJECTIVES OF THE STUDY:

1. To study endothelial dysfunction in patients with hypertension & compare with non-hypertensive subjects.
2. To correlate duration of hypertension with prevalence of endothelial dysfunction.
3. To correlate microalbuminuria with endothelial dysfunction in essential hypertension.
4. To correlate risk factors of atherosclerosis in essential hypertension with endothelial dysfunction.

MATERIALS AND METHODS: This study was done between September 2004 and September 2006. All patients with hypertensionwere included in the study.This is a case control observational study, which had sample size of 50 subjects and 20 controls who are healthy individuals.

Method of collection of data: Method of collection of data was done by evaluation, which was done by taking detailed history, clinical examination and laboratory investigations through proforma specially designed for this study.

Inclusion criteria

Age 30-60 years.
Both sexes.
Newly detected hypertensives and hypertensives on treatment with anti-hypertensives.
Patients with only essential hypertension.

Exclusion criteria

Age <30 years and >60 years.
Patients who do not give consent for the study.
Secondary hypertension.
Diabetic patients.
Previous myocardial infarction.
Smokers.

The patients with hypertension and controls were included in the study. Colour Doppler ultrasonography of the brachial artery, by HEWLETT-PACKARD Image point machine using 7.5 and 10 MHz Linear probe was performed to assess FMD, which provides information regarding endothelial function. Total cholesterol, HDL and TGs was measured byautomatic analyzer with Reagent kit. Cholesterol levels were measured by enzymatic method. LDL was calculated with Friedewald's formula - LDL cholesterol = Total cholesterol – (HDL – TGs / 5).Dyslipidaemia was defined as LDL level ≥ 130mg/dl or HDL≤ 40mg/dl or TGs ≥ 200mg/dl. (ATP III guidelines).[29]

All the patients were subjected to the following investigations before entering the study.

Hb%
TC, DC, ESR.
FBS and PPBS
Urine routine
Blood urea and Serum creatinine
Lipid profile
ECG
Fundoscopy

Colour Doppler ultrasonography of the brachial artery, by HEWLETT-PACKARD Image point machine with colour Doppler using 7.5 and 10 MHz linear probe.

Urine for microalbuminuria by albumin/creatinine ratio by spot method.
USG abdomen.
2D ECHO.
X ray chest PA view.

STATISTICAL METHODS: Chi-square and Fisher exact test have been used to test the Significance of proportion of study parameters between cases and control. 95% Confidence interval has been used

to find the significance of percentage of study parameters. Student t test has been used to significance of study parameters including the parameters of FMS assessmentbetween cases and controls.

Statistical software: The statistical software namely SPSS 11.0 and Systat 8.0 were used for the analysis of the data and Microsoft word and Excel have been used to generate graphs, tables etc.

ETHICAL CLEARANCE: This study was approved by ethical committee of this Institute.

RESULTS: A case-control study consisting of 50 cases and 20 controls is undertaken to study-the endothelial dysfunction and lipid parameters and risk factors associated with the endothelial dysfunction.

AGE DISTRIBUTION (figure 1a): In this study, age distribution among the cases was 24% between 30-40 years, 26% between 41-50 years and 50% between 51-60 years. Among the controls, age distribution was 10% between 30-40 years, 15% between 41-50 years and 75% between 51-60 years.

SEX DISTRIBUTION (figure 1b): In the present study, it is observed that males were (58%) and females (42%) among cases. In control group,males were (75%) and females (25%).

DURATION OF HYPERTENSION (figure 2): In this study it is seen that in most of the cases 23 (46.0%), the duration of hypertension was between 1-4 years followed by 14 (28%) which were < 1 year and13 (26%) between 5-10 years.

FAMILY HISTORY IN CASES (figure 3): In present study, majority of them had family history of hypertension 22 (40%), followed by DM 12 (24%) and then CAD 6 (12%).

CLINICAL FEATURES (figure 17): In the present study, majority of the cases had giddiness i.e. 5 (10%) as one of the prominent clinical feature.

FOOD HABITS (figure 5): In the present study, majority had mixed diet 30 (60%) and vegetarians were 20 (40%).

BMI DISTRIBUTION (figure 6): In this present study majority 26 (52%) had BMI between25-29.9, followed by 12 (24%) with BMI ≤ 24.9; 12 (24%) with BMI 30 and above.

WAIST- HIP RATIO (figure 7):In this present study majority 26 (52%) had BMI between25-29.9, followed by 12 (24%) with BMI ≤ 24.9; 12 (24%) with BMI 30 and above.

LIPID PARAMETERS (figure 8):In this present study HDL was low(< 40 mg/dl) in 35 (70%) of patients.

Abnormal total cholesterol	24 (48%)
Abnormal LDL	21 (42%)

Triglycerides	16 (32%)

ENDOTHELIAL DYSFUNCTION (figure 9): In this present study HDL was low(< 40 mg/dl) in 35 (70%) of patients.

Abnormal total cholesterol	24 (48%)
Abnormal LDL	21 (42%)
Triglycerides	16 (32%)

In this present study, the mean age of male cases having endothelial dysfunction is 50.56 and female 48.83 with a range of 35-60 yrs respectively. Among the 9 male cases who had endothelial dysfunction 5 had family history of hypertension, 3 had family history of CAD, 3 had family history of DM. Majority of male cases who had endothelial dysfunction were with duration of hypertension between 5-10 years and for females it was <1year. Females had more number of abnormal total cholesterol whereas males had more number of HDL and triglycerides.

BASIC DEMOGRAPHIC AND ANTHROPOMETRIC PARAMETERS COMPARISON BETWEEN TWO GROUPS (figure 11): Mean value of cases for age in years is 49.06±9.55 slightly lesser than 56.35±10.46 with p value of 0.007.

Height in cms for cases 170.52±9.68 and 161.50±7.24 with p value <0.001.Weight in kgs 80.54±8.58 for cases and 56.80±8.95 with p value <0.001.BMI (kg/m^2) 27.83±3.40 for cases and 21.05±2.69 with p value < 0.001.Waist (cms) 37.24±3.00 for cases and 93.65±5.60 with p value < 0.001.Hip (cms) 43.80±3.90 for cases and 93.65±25.60 with p value < 0.001.Waist/hip ratio 0.85±0.004 for cases and 0.87±0.05 with p value 0.115.

BASIC LIPID PARAMETERS COMPARISON BETWEEN TWO GROUPS (figure 12): In this study, serum cholesterol in hypertensives was 195.80±38.87 significantly higher in cases than controls (165.20±38.53), LDL (122.00±39.81) in cases and 95.00±25.07.HDL 36.54±8.55 in cases remains equal to controls, 161.35±99.87. Triglycerides 199.08±86.80 were higher than controls 161.35±99.87.VLDL 37.26±11.32 was almost equal to controls 33.70±15.56.

ASSOCIATION OF FMD WITH RISK FACTORS IN HYPERTENSION (figure 15):In this study, it is observed that the mean age for FMD > 4.5% is 48.71±9.91 and FMD <4.5% is 49.87±8.92. Age is higher in hypertensives with FMD% < 4.5. Females who had FMD > 4.5% were 42.8% and 40% with FMD > 4.5%. In the family history of hypertension 6 (40%) had FMD < 4.5% and 116 (45.7%) had FMD > 4.5%.Coming to the duration of hypertension < 5 years, 9 (60%) had FMD < 4.5% and 28 (80%) had FMD of > 4.5%. In hypertension > 5 years 6 (40%) had FMD < 4.5% and 7 (20%) had FMD > 4.5%.BMI is slightly lower in cases with FMD < 4.5% (27.52±3.60) compared to FMD > 4.5% (27.96±3.35).Values suggesting truncal obesity i.e. waist hip ration did not show any relation to endothelial dysfunction with values 0.85±0.03 and 0.85±0.5 for FMD < 4.5% and for FMD > 4.5% respectively.

ASSOCIATION OF MICROALBUMINURIA WITH ENDOTHELIAL DYSFUNCTION (figure 16):Microalbuminuria was present in 4 (33.3%) of cases who had FMD < 4.5% and in 8 (66.7) of cases with FMD > 4.5%.Thus microalbuminuria does not correlate withendothelial dysfunction.

DISCUSSION: The heart, brain and kidney are the major target organs for the effects of hypertension.[7,8] The serious complications are not only the consequences of increased blood pressure, but are also related to the arterial endothelial dysfunction abnormal endothelial function accelerates the process of hypertension. [7,810,11,19,27] The earliest clinical evidence of nephropathy is the appearance of albumin in the urine, referred to as microalbuminuria.[7,8,31,32] Essential hypertensive with microalbuminuria supports the hypothesis that abnormal UAE reflects the systemic dysfunction of vascular endothelium.[6,20,30]Several studies have shown that endothelial function is impaired in patients with coronary heart disease, diabetes, hypercholesterolemia, obesity and cigarette smoking.[5,8] Therefore, to avoid any potential compounding factors, the 2 groups of subjects were carefully selected to be compared between hypertensives and controls. Thus, the impaired response to reactive hyperemia found in hypertensive patients compared with normotensive subjects is likely to attribute to the presence of hypertension.[38]

In this study, it was noticed that majority 25 (50%) of the cases were in the age group of 51-60 years, followed by 13 (26%) were between 41-50 years. The remaining cases were below the age of 41 years.The mean age for control was 56.35±10.46 and among the cases the non-microalbuminurics were 48.82±9.70 and microalbuminurics were 49.83±9.44 with p value of 0.024.The Roberto Fedrinelli study[20] noticed that the mean±SD for controls was 58.5±9, non-microalbuminurics was (60.1±9.1) and microalbuminurics 59.4 (9) which is significantly higher compared to cases in our study.

In my study, controls had 15 males and 5 females. Among non-microalbuminurics 20 were males and 18 were females. Among the microalbuminurics 9 were males and 3 were females. Males are more in number compared to females among the microalbuminurics.In Roberto Fedrinelli study[20], only males were involved.

In the present study BMI of the controls were 21.05±2.69, non-microalbuminurics was 27.62±3.41 and microalbuminurics 23.49±3.42 with p value <0.001. In Roberto Fedrinelli study[20] of controls were 24.5±2.3, non-microalbuminurics 25.3±2.9 and microalbuminurics 25.8±3.6.BMI among the cases is high compared to controls as well as Roberto Fedrinelli study[20]. Microalbuminurics had high BMI than non-microalbuminurics.

Therefore, BMI is one of the influential factor of FMD.

In the present study controls had 0.87±0.05;non-microalbuminurics had 0.86±0.04; microalbuminurics had 0.85±0.04 with p value 0.242.WHR was almost equal to that of controls.In present study the SBP among controls were 122.61±5.56, non-microalbuminurics 137.16±15.96; microalbuminurics had 141.33±13.60 with p value of 0.419.In Roberto Fedrinelli study[20] controls had SBP 135±8; non-microalbuminurics 162±19 and microalbuminurics 164±12.

In present study controls had DBP of 78.69±4.54;non-microalbuminurics had 90.42±6.76 and microalbuminurics 92.67±7 with p value 0.428.In Roberto Fedrenelli study[20] controls had DBP of 81.0±7, non-microalbuminurics 100±17 and microalbuminurics had 98.07±7.

In the present study, controls had Total cholesterol 165.20±38.35, LDL 95.50±25.07; HDL 36.00±5.70, TGL 161.35±99.87, VLDL 33.70±15.56, FBS 94.56±13.01, PPBS 110.40±19.44.Non-

microalbuminurics had TC 190.65±39, LDL 116.84±40.07, HDL 37.79±8.76, TGL 181.92±57.82, VLDL 35.50±10.52, FBS 107.50±6.53, PPBS 126.17±9.51, with p value ranging from 0.004 to<0.001.In Roberto Fedrinelli study[20] controls had TL 501±.7; HDL 106±0.09 LDL 328±0.69; TG 142±0.56.Non-microalbuminurics had TL 571±0.64, HDL0.8±0.02, LDL 411±0.64, TG 174±0.64, microalbuminurics had TL 58.8±109, HDL 0.83±0.3; TG 157±0.38.LDL is higher among cases compared to controls and significantly lower compared to Roberto Fedrenelli study.[20]Microalbuminurics have higher levels of LDL compared to non-microalbuminurics.Abnormal HDL is higher in cases compared to controls as well as Roberto Fedrinelli study[20]. Blood sugar was higher in cases compared to controls.

In present study controls had baseline diameter 5.61±0.54; baseline flow 661.95±164.55, reactive hyperaemia flow 780.59±356.57, Hyperaemia flow 168.21±98.24; FMD 5.03±2.80.Microalbuminurics had baseline diameter 4.39±0.68; baseline flow 631.07±175.56; reactive hyperaemia flow 1001.4±411.84; hyperaemia flow 142.10±93.59, FMD 4.64±1.25.McMeuirranet al study[10], controls had baseline diameter 3.98±0.16; baseline flow 117±14; hyperaemia % 675±73; FMD% 9.3±1.8. Among hypertensives, baseline diameter was 4.35±0.1, baseline flow 131±9.4; hyperaemia 568±39 and FMD% 3.8±0.5.

In Jiang Li et al study[11] controls had baseline diameter 3.8±0.5;flow 117.9±41.3; hyperaemia %342.9±117.1%, FMD% 12.4±2.9%.Among cases, baseline diameter 400±0.6, baseline flow 115.1±49.4, hyperaemia % 319.4±115.2; FMD % 4.6%±2.8.Baseline diameter is higher in cases compared to controls as well as the studies conducted. Microalbuminurics had higher baseline flow compared to non-microalbuminurics.FMD is significantly lower in cases as compared to controls; microalbuminurics had FMD significantly lower than non-microalbuminurics.

CONCLUSION: In this study, of 50 hypertensives, endothelial dysfunction was present in15 (30%) cases. Endothelial dysfunction was more common in males 9(60%) and females 6 (40%).

Endothelial dysfunction was present in all hypertensive cases irrespective of its duration of onset and prevalence of endothelial dysfunction did not increase with duration of hypertension.

The endothelial dysfunction is independent of Body mass index, High density lipoprotein, duration of hypertension and microalbuminuria but dependent on Triglycerides, Low density lipoprotein and Flow-mediated dilatation.

LIST OF ABBREVIATIONS

ACE	→	Angiotensin Converting Enzyme
AEC	→	Albumin Excretion Rate
BMI	→	Body Mass Index
CAD	→	Coronary Artery Disease
CVA	→	Cerebrovascular Accident
ED	→	Endothelial Dysfunction
EDRF	→	Endothelin Derived Releasing Factor
FBS	→	Fasting Blood Sugar
FMD	→	Flow Mediated Dilatation
HDL	→	High Density Lipoprotein

HDL	→	High-density Lipoprotein
HTN	→	Hypertension
IHD	→	Ischaemic Heart Disease
LDL	→	Low Density Lipoprotein
NO	→	Nitric Oxide
PPBS	→	Postprandial Blood Sugar
TCH	→	Total Cholesterol
TG	→	Triglycerides
UAE	→	Urinary Albumin Excretion
US	→	Urine Sugar
VLDL	→	Very Low Density Lipoprotein
WHR	→	Waist Hip Ratio

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Age in years	Cases			Controls		
	Male	Female	Total	Male	Female	Total
30-40	6 (20.7%)	6 (28.6%)	12 (24.0%)	2 (13.3%)	-	2 (10.0%)
41-50	8 (27.6%)	5 (23.8%)	13 (26.0%)	3 (20.0%)	-	3 (15.0%)
51-60	15 (51.7%)	10 (47.6%)	25 (50.0%)	10 (66.7%)	5 (100.0%)	15 (75.0%)
Total	29 (100.0%)	21 (100.0%)	50 (100.0%)	15 (100.0%)	5 (100.0%)	20 (100.0%)

Table 1: Age and sex distribution of cases and controls

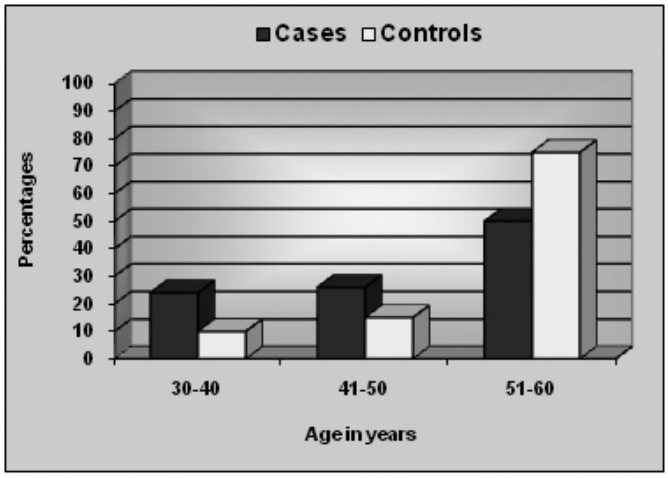

Fig. 1a: Age distribution in case and control

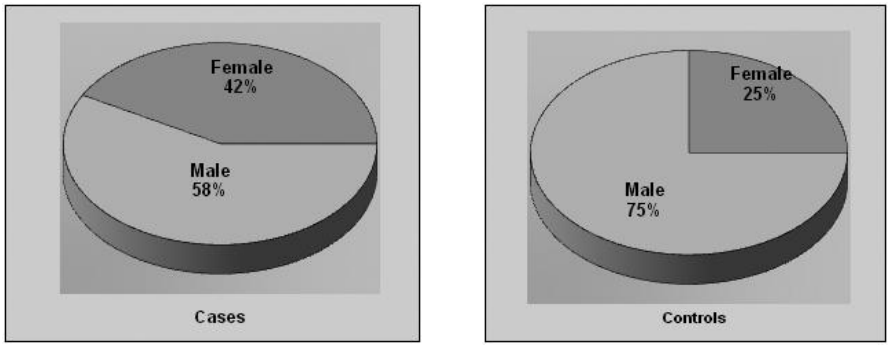

Fig. 1b: Sex distribution

Duration of hypertension	Number	%
<1 years	14	28.0
1-4 years	23	46.0
5-10 years	13	26.0
Total	50	100.0

Table 2: Duration of hypertension

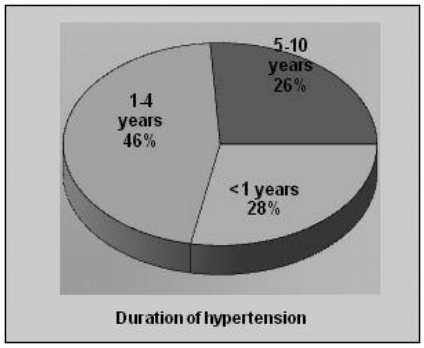

Fig. 2: Duration of hypertension

Family history	Number (n=50)	%
Hypertension	22	44.0
CAD	6	12.0
DM	12	24.0

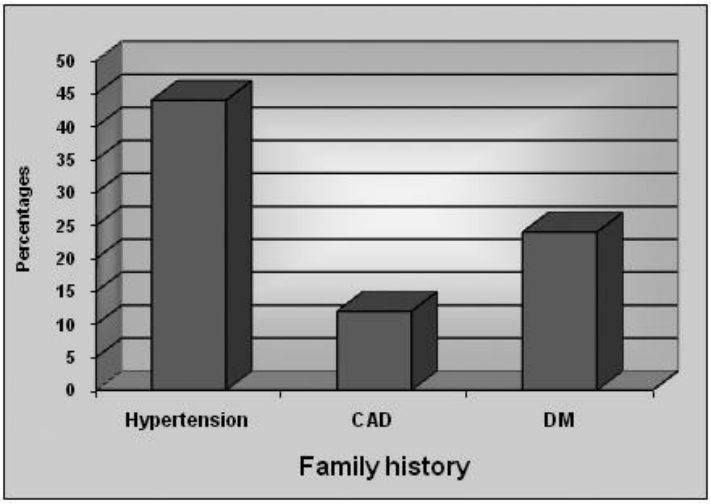

Fig. 3: Family history

Clinical features	Number (n=50)	%
Giddiness	5	10.0
Headache	3	6.0
Both	1	2.0

Table 4: Clinical features

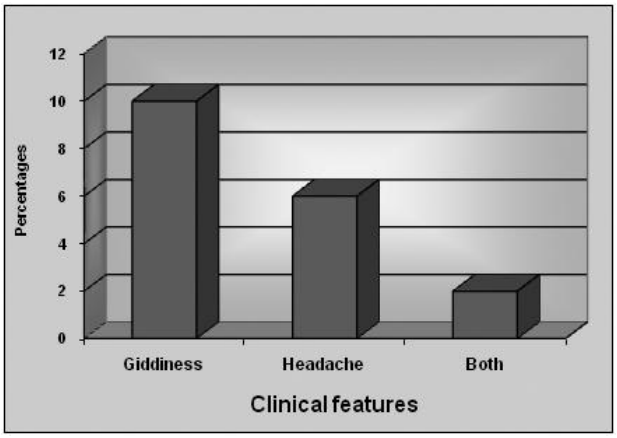

Fig.4: Clinical features

Food habits	Number (n=50)	%
Vegetarian	20	40.0
Mixed	30	60.0

Table 5: Food habits

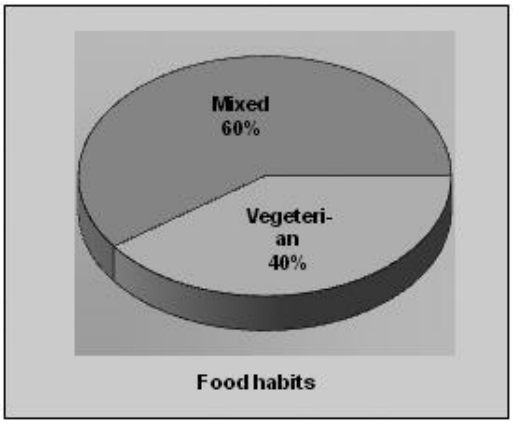

Fig. 5: Food habits

BMI	Number (n=50)	%
≤ 24.9	12	24.0
25-29.9	26	52.0
30 & above	12	24.0

Table 6: Distribution of cases by BMI in different groups

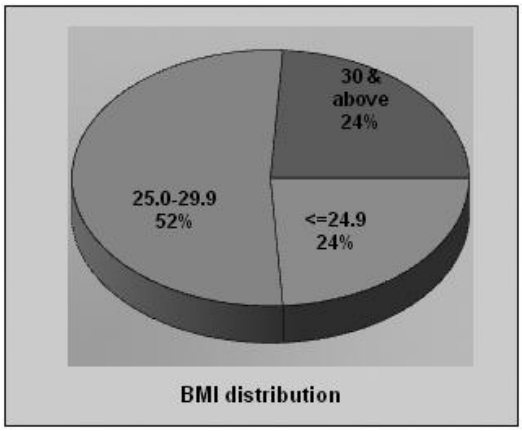

Fig. 6: BMI distribution

Waist hip ratio	Number (n=50)	%
Normal	33	66.0
Abnormal (Male>0.90, Female >0.85)	17	34.0

Table 7: Distribution of cases by Waist-hip ratio in different groups

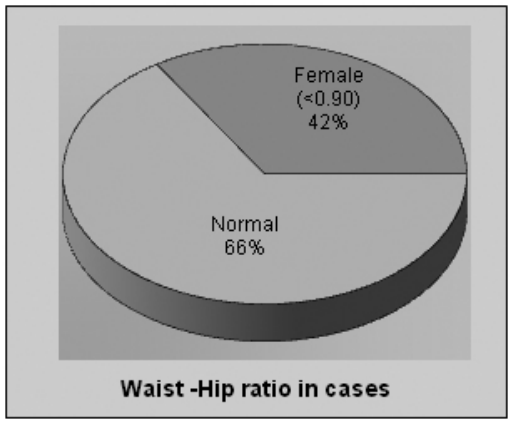

Fig. 7: Waist –Hip ratio in cases

Lipid parameters	Number (n=50)	%	95%CI
Total cholesterol (≥ 200 mg/dl)	24	48.0	34.80-61.49
LDL (≥ 130mg/dl)	21	42.0	29.38-55.77
HDL (≤ 40 mg/dl)	35	70.0	56.25-80.90
Triglycerides (≥ 200mg/dl)	16	32.0	20.76-45.81
Inference	Abnormal HDL is significant in the present study with 95%CI (56.25-86.90%)		

Table 8: Distribution of cases by abnormal lipid parameters

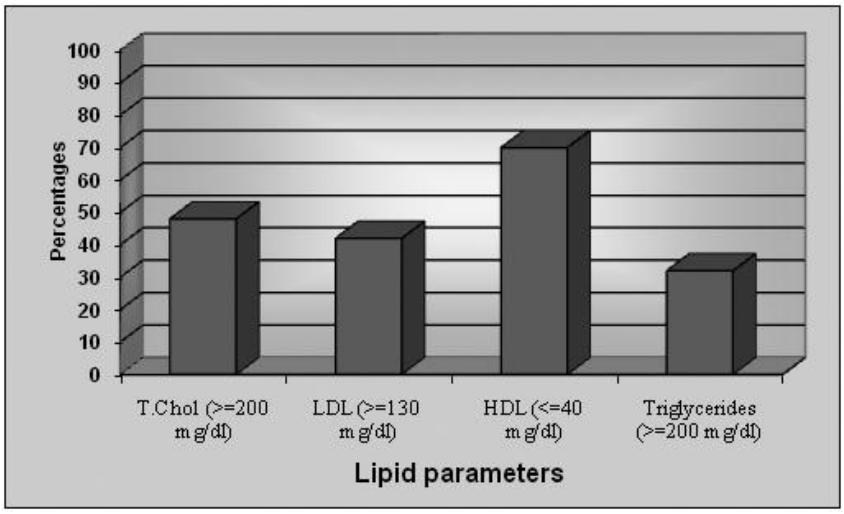

Fig. 8: Abnormal lipid parameters

Endothelial dysfunction	Cases	Controls
Absent (≥ 4.5)	35 (70.0%)	20 (100.0%)
Present (<4.5)	15 (30.0%)	-
Inference	Endothelial dysfunction is significantly more in cases (p=0.004)	

Table 9: Distribution of subjects based on endothelial dysfunction

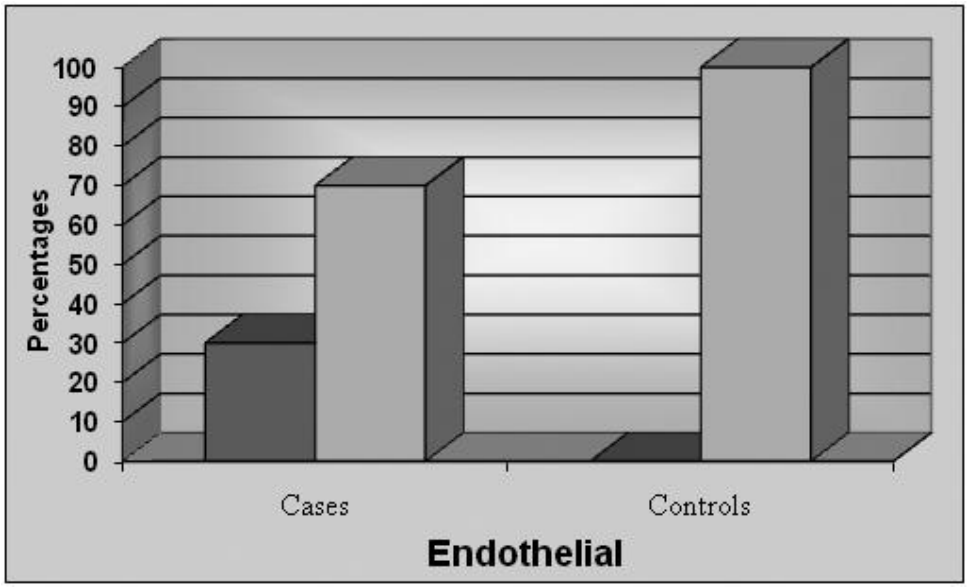

Fig. 9: Endothelial dysfunction

Endothelial dysfunction	Number of patients having Endothelial dysfunction		
	Male	Female	Total
Age in years			
Mean ± SD	50.56	48.83	49.87
Range	35-60	35-56	35-60
Sex	9	6	15
Family history of Hypertension	5	1	6
Family history of CAD	3	-	3
Family history of DM	3	3	6
Duration of Hypertension			
<1 years	-	3	3
1-4 years	4	2	6
5-10 years	5	1	6
Total	9	6	15
Obesity	2	2	4
Abnormal lipid parameters			
Total cholesterol ≥ 200 mg/dl	3	5	8
LDL≥ 130 mg/dl	3	5	8
HDL ≤ 40 mg/dl	5	-	5
Triglycerides ≥ 200 mg/dl	4	1	5

Table 10: Distribution of subjects having endothelial dysfunction by different risk factors

Basic demographic and Anthropometric parameters	Case		Control		p value
	Mean	SD	Mean	SD	
Age in years	49.06	9.55	56.35	10.46	0.007**
Height in cm	170.52	9.68	161.50	7.24	<0.001**
Weight in kg	80.54	8.58	56.80	8.95	<0.001**
BMI (kg/m^2)	27.83	3.40	21.05	2.69	<0.001**
Waist (cms)	37.24	3.10	81.75	7.69	<0.001**
Hip (cms)	43.80	3.90	93.65	5.60	<0.001**
Waist/Hip ratio	0.85	0.04	0.87	0.05	0.115

Table 11: Basic demographic and anthropometric parameters comparison between two groups

Lipid parameters	Case		Control		p value
	Mean	SD	Mean	SD	
Total cholesterol	195.80	38.87	165.20	38.53	0.004**
LDL	122.00	39.81	95.50	25.07	0.007**
HDL	36.54	8.55	36.00	5.70	0.796
Triglycerides	199.08	86.80	161.35	99.87	0.120
VLDL	37.26	11.32	33.70	15.56	0.291

Table 12: Basic lipid parameters comparison between two groups

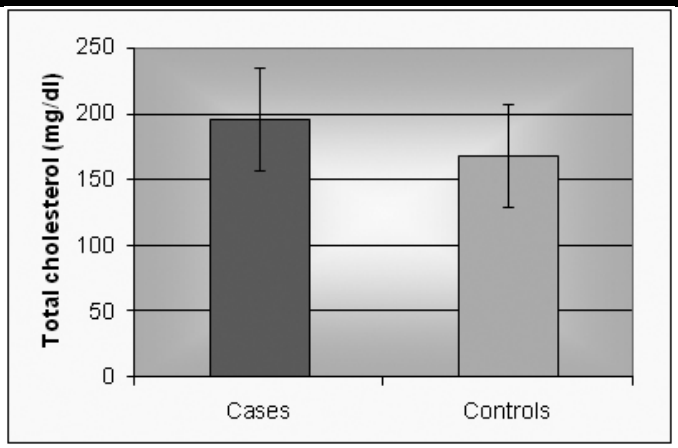

Fig. 10: Showing the total cholesterol between cases and controls

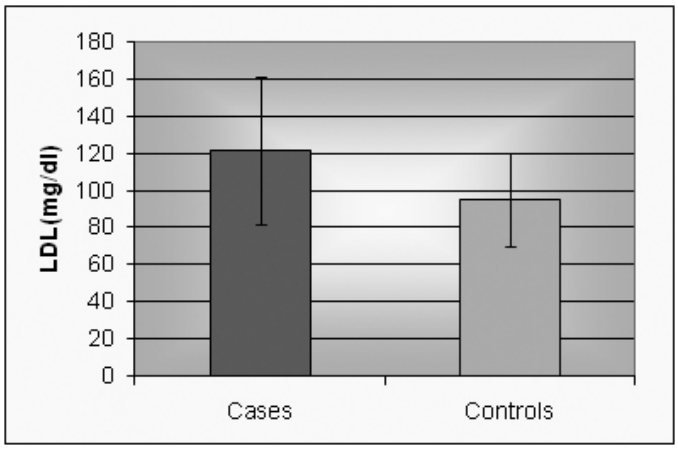

Fig. 11: Showing the LDL between cases and controls

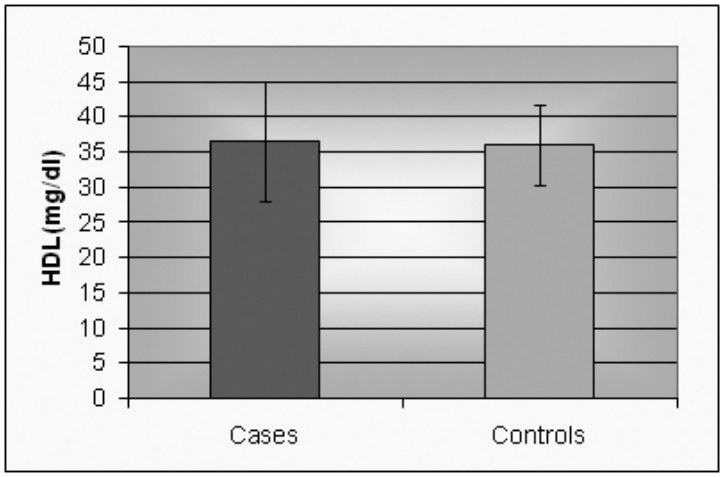

Fig. 12: Showing the HDL between cases and controls

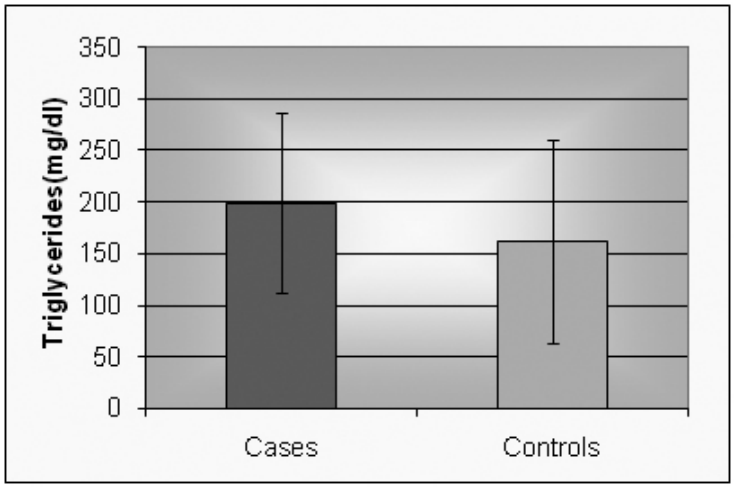

Fig. 13: Showing the Triglyceridesbetween cases and controls

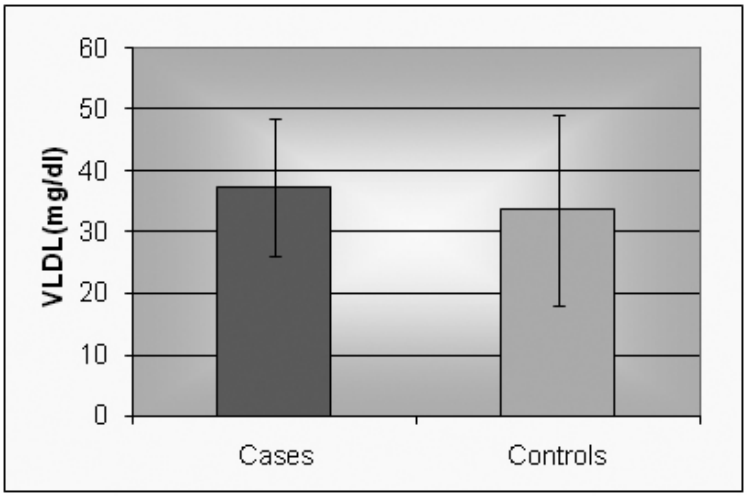

Fig. 14: Showing the VLDL between cases and controls

Parameters of FMD assessment	Case		Control		p value
	Mean	SD	Mean	SD	
Baseline diameter	4.24	0.66	3.61	0.54	<0.001**
Baseline flow	1033.75	453.18	780.59	356.57	0.471
Reactive hyperemic flow	161.96	96.85	122.97	55.39	0.029*
Hyperemic flow%	626.46	192.73	661.95	164.35	0.096+
FMD%	4.93	2.52	17.01	10.68	<0.001**

Table 13: Comparison measure parameters of FMD assessment between two groups

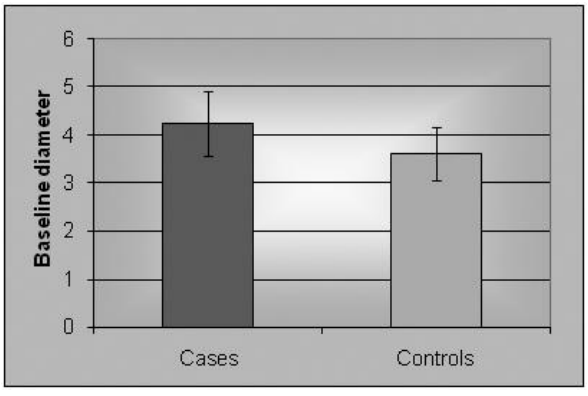

Fig. 15: Showing the mean baseline diameter

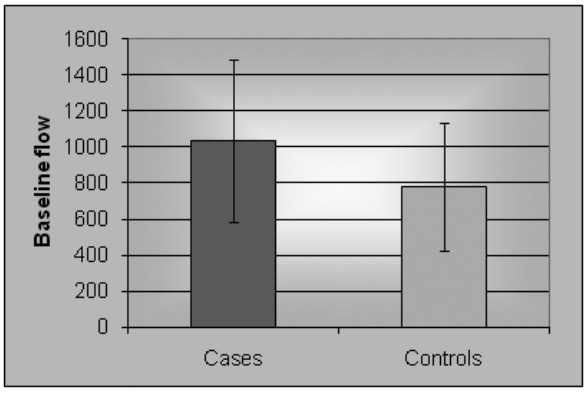

Fig. 16: Showing the mean Baseline flow

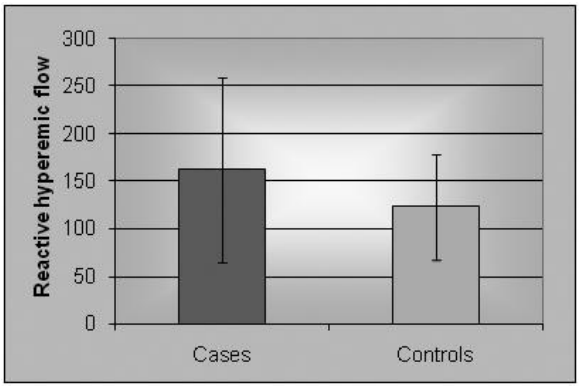

Fig. 17: Showing the mean reactive hyperemic flow

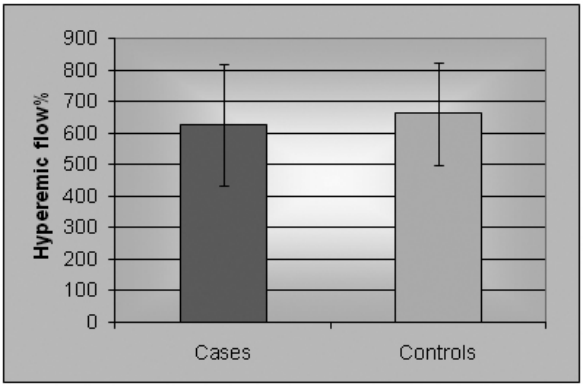

Fig. 18: Showing the mean hyperemic flow %

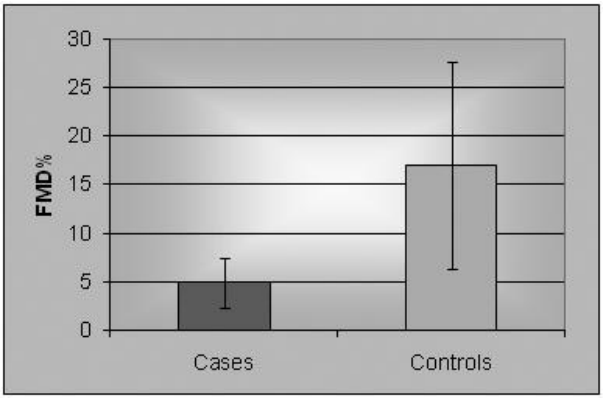

Fig. 19: Showing the mean FMD%

Duration of hypertension	Number	FMD(<4.5%)
<1 years	14	3 (21.4%)
1-4 years	23	6 (26.1%)
5-10 years	13	6 (46.2%)
Total	50	15 (30.0%)

Table 14: Duration of hypertension and FMD

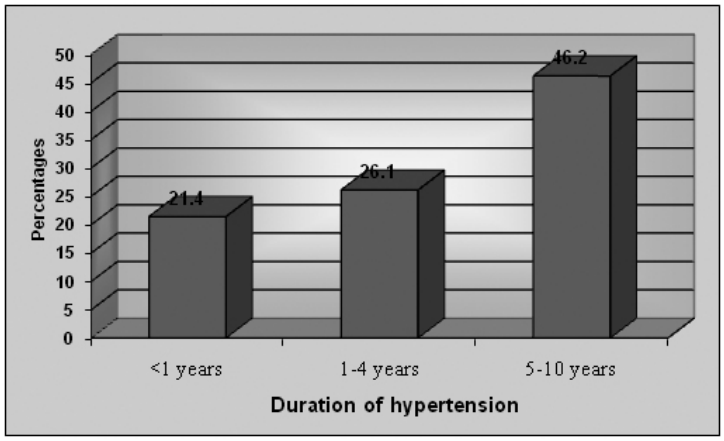

Fig. 20: Showing the duration of hypertension

Risk factors	FMD%		P value
	>4.5%	<4.5%	
Age in years	48.71±9.91	49.87±8.92	0.700
Sex	Male(57.1%) Female(42.8%)	Male (60.0%) Female (40.0%)	0.851
Smoking	-	-	-
Alcohol	-	-	-
Family history of HTN	16(45.7%)	6(40.0%)	0.709
Duration of HTN			
<5 yrs	28(80.0%)	9 (60.0%)	0.170
>5 yrs	7 (20.0%)	6(40.0%)	
BMI kg/m^2	27.96±3.35	27.52±3.60	0.679
Waist Hip Ratio	0.85±0.05	0.85±0.03	0.938
Total cholesterol (mg/dl)	188.91±36.72	211.40±40.31	0.061+
LDL (mg/dl)	116.06±37.24	135.87±43.39	0.108
HDL (mg/dl)	36.54±9.23	36.53±0.997	0.997
Triglycerides (mg/dl)	203.06±99.57	189.80±0.626	0.626
VLDL (mg/dl)	37.00±12.24	37.87±0.807	0.807

Table 15: Association of FMD with risk factors in hypertension

Non-microalbuminuria	Microalbuminuria	FMD		Total
		>4.5%	<4.5%	
<30 mg/dl		27 (71.1%)	11(28.9%)	38
	>30 mg/dl	8(66.7%)	4(33.3%)	12
Total		35(70.0%)	15(30%)	50
Inference		Presence of microalbuminuria is not correlating with endothelial dysfunction (p=0.999)		

Table 16: Association of Microalbuminuria with endothelial dysfunction

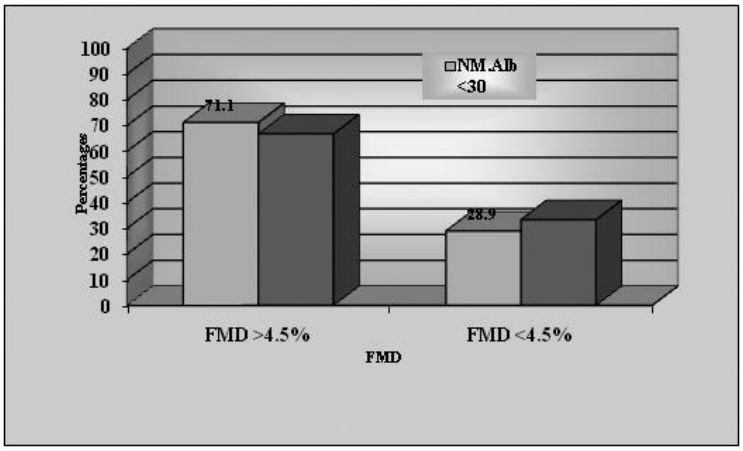

Fig. 21: Association of Microalbuminuria with endothelial dysfunction

	Control	Non-Microalbuminurics	Microalbuminurics	p value
Age	56.35±10.46	48.82±9.70	49.83±9.44	0.024
Sex	M-15; F-5	M-20; F-18	M-9; F-3	
BMI	21.05±2.69	27.62±3.41	28.49±3.42	<0.001
WHR	0.87±0.05	0.86±0.04	0.85±0.04	0.242
SBP/DBP	122.61±5.56	137.16±15.96	141.33±13.60	0.419
DBP	78.69±4.54	90.42±6.76	92.67±7.49	0.428
Biochemical characteristics				
TCL	165.20±38.35	190.65±39.82	213.55±30.61	0.004
LDL	95.50±25.07	116.84±40.07	138.3±35.71	0.006
HDL	36.00±5.70	37.79±8.76	32.58±6.68	0.127
TGL	161.35±99.87	181.92±57.82	253.42±134.46	0.016
VLDL	33.70±15.56	35.50±10.52	42.83±12.39	0.123
FBS	94.56±13.01	107.50±9.25	111.50±11.12	<0.004
PPBS	110.40±19.44	126.71±8.86	126.17±9.51	

Table 17: Clinical characteristics

	Control	Non-microalbuminuria	Microalbuminuria	p value
Baseline diameter	3.61±0.54	419±0.66	4.39±0.68	0.001
Baseline flow	661.95±164.35	625.02±200.07	631.02±175.56	0.769
Reactive hyperaemic flow	780.59±356.57	1043.97±470.2	1001.40±411.84	0.089
Hyperanemic flow(%)	122.97±55.39	168.21±98.24	142.16±93.59	0.169
FMD	17.01±10.68	5.03±2.80	4.64±1.29	<0.001
Character of the brachial artery vasoactivity				

AUTHORS:

1. Arvind M.N.
2. V. Channaraya

PARTICULARS OF CONTRIBUTORS:

1. Assistant Professor, Department of General Medicine, Kempegowda Institute of Medical Sciences and Research Institute, K.R. Road, V.V. Puram, Bangalore.
2. Professor, Department of General Medicine, Kempegowda Institute of Medical Sciences and Research Institute, K.R. Road, V.V. Puram, Bangalore.

NAME ADRRESS EMAIL ID OF THE CORRESPONDING AUTHOR:

Dr. Arvind M.N.
42/1, 9th Main, 4th Cross,
RMV Extension, Sadashivnagar,
Bangalore – 560080, Karnataka, India.
Email – drarvind_mn@yahoo.co.in

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