Original Article

Impact of Carotid Intima-Media Thickness on Long-term Outcome in Hemodialysis Patients

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Abstract

Background: Chronic kidney disease (CKD) patients on hemodialysis are highly prone to cardiovascular disease, which accounts for roughly half of the mortality in these patients. Atherosclerosis begins many years before the development of clinical manifestations. Measurement of carotid intima-media thickness (CIMT) is a noninvasive procedure to detect early atherosclerotic changes. **Aims:** The aim of the study was to evaluate the correlation between CIMT and cardiovascular risk factors and to investigate its prognostic significance in CKD patients on hemodialysis. **Materials and Methods:** This was a prospective study carried out over a period of 18 months. Total 88 patients on hemodialysis and 50 healthy controls were enrolled in the study. Biochemical assay and CIMT was assessed using the high resolution 7.5 MHz sonography technique in all subjects. **Results:** Significant positive correlation was found with age, blood urea, serum creatinine, serum triglyceride, low-density lipoprotein, serum phosphorus, serum calcium-phosphorus product, serum uric acid, 24 h urine protein, systolic blood pressure, diastolic blood pressure, and body mass index. Negative correlation was found with estimated glomerular filtration rate. Adjusted hazards ratios of all cause and cardiovascular mortality for an increase of 0.1 mm in CIMT was 1.16 (95% confidence interval 0.15-9.09). Patients with CIMT value <0.97 mm had a renal survival rate of 73.4% while patients with value >0.97 mm had a renal survival rate of 16.5%. **Conclusion:** Uremia is an additive risk factors in those subjects who have raised CIMT despite of traditional cardiovascular risk factors.

Keywords: Carotid intima-media thickness, Hemodialysis, Outcome

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Introduction

Cardiovascular disease (CVD) is the leading cause of morbidity and mortality in chronic kidney disease (CKD) patients, accounting for 40% of hospitalization, and almost 50% of deaths. The risk of death from CVD is elevated 30-fold for patient with end-stage renal disease (ESRD) as compared to the general population. At the time of starting renal replacement therapy, prevalence of CVD among CKD patient is high.[1,2] It has been widely shown that the cardiovascular status at the beginning of dialysis greatly affects patients outcome.

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There is accumulating evidence that the increase in CVD burden is present in patients prior to dialysis, due to both conventional risk factors as well as those specific to kidney disease.[3]

Atherosclerosis begins many years before the development of clinical manifestations.[4,5] Studies have shown that hemodialysis patients have advanced changes in the walls of their arteries, which can present as increased intima-media thickness (IMT) in the carotid and femoral arteries.[6,7] The pathophysiological mechanisms of atherosclerosis in CKD patients are not yet fully established. However, it is known that in addition to the traditional risk factors described in the Framingham Heart Study, other factors related to uremia such as hyperphosphatemia and hyperparathyroidism play a role in the development of the disease in this population.[8-10]

Carotid intima-media thickness (CIMT) has been reported as representative of subclinical and asymptomatic

atherosclerotic vascular diseases and therefore CIMT is a procedure to detect early atherosclerotic changes. The visualized lesion in the common carotid artery (CCA) has been reported to correlate to the degree of atherosclerotic lesions elsewhere in the body. Hence, the measurement of the IMT by ultrasonography of the carotid artery is been presently recommended for cardiovascular risk assessment.[11] CIMT is a self-determining predictor of coronary heart disease after adjustment of the other risk factors for CVDs.[12,13] Some studies have indicated CIMT as a predictor of cardiovascular events in patients undergoing hemodialysis.[14-17] The study was conducted to establish a correlation between CIMT and cardiovascular risk factors and to investigate its prognostic significance in CKD patients on hemodialysis.

Materials and Methods

After Ethical Clearance from Institutional Ethic Committee, this prospective study was carried out in Department of Medicine, K.G. Medical University, Lucknow, Uttar Pradesh, India during August 2013-January 2015.

Study population

Patients with CKD stage-V, age between 18 and 65 years, who were on maintenance hemodialysis for at least 6 months in the nephrology unit, fulfilling the inclusion criteria of the study and provided written consent for participation were included in the study as per Kidney Disease Improving Global Outcomes guidelines 2012. Age and gender matched 50 healthy control were also enrolled in the study. Patients suffering with septicemic acute renal failure, history of CVD, malignancy, hypothyroidism, inflammatory disorder, and those subjects who are not willing to take part in the study were excluded from the study.

Clinical evaluation

The estimated glomerular filtration rate of <60 mL/min/1.73 m^2 for 3 months was defined as CKD. CKD stage-V defined as estimated glomerular filtration rate of <15 mL/min/1.73 m^2. Modification of diet in renal disease formula was used to calculate the estimated glomerular filtration rate. Hypertension was defined as systolic blood pressure ≥140 mmHg or diastolic blood pressure ≥90 mmHg. Obesity was defined as body mass index (BMI) >25 kg/m^2 (as opposed to 30 kg/m^2 at the international level) and hyperlipidemia was defined as plasma cholesterol levels ≥240 mg/dL or plasma low-density lipoprotein (LDL) levels ≥160 mg/dL or plasma triglyceride levels ≥150 mg/dL electrocardiogram (ECG) was recorded just before the starting of dialysis. The presence of abnormal Q or inverted T wave in extremity leads was defined as ischemic ECG changes.

All the patients had been subjected to regular hemodialysis for 4 h 3 times a week at a blood flow rate of 180-220 mL/min using bicarbonate dialysate (30 mEq/L) at a flow rate of 500 mL/min. Usage of polysulfone dialyzer membranes: Low-flux ultrafiltration rate (UFR) (20 mL/min), medium-flux UFR (20-40 mL/min), and high-flux UFR (40 mL/min) was included in hemodialysis. The dialyzer membrane was not reused in any of patients, neither bacteria nor pyrogen was detected in the dialysate prepared from water obtained by reverse osmosis.

Biochemical assay

Five milliliter of venous blood sample was withdrawn with full aseptic precaution after an overnight fast from both cases and controls. The blood was centrifuged at 5000 rpm for 10 min at room temperature, serum was separated for routine hematology, biochemistry, urinalysis, and urine protein measurements were performed. An automated blood-cell analyzer (BC-5380, Mindray, China) was used for routine hematology testing, and an automated clinical biochemistry analyzer (Cobas C 311, Roche-Hitachi, Japan) was used to measure blood urea, serum creatinine, serum uric acid, serum lipids, serum electrolytes, and serum albumin. Corrected calcium was calculated by using formula: Corrected calcium = 0.8 (4-serum albumin) + serum calcium (mg/dL).

Carotid ultrasound

Carotid Doppler ultrasonography was performed by a single operator expert ultrasonologist and CIMT was measured in the Department of Radiology; the operator was blinded about the history and laboratory findings of the patients. The CIMT was defined as a hypo-echogenic space between two echogenic lines containing intima-media interface and media-adventitia interface on the posterior wall of the carotid artery. For performing carotid Doppler ultrasonography, the patient was asked to lie down on the examination table in the supine position. His/her neck was rotated in a superior and leftward direction, so that the right carotid artery was exposed. Following this, using a 7.5 MHz linear array transducer with high-resolution B-mode ultrasonography system (G E LOGIQ TOSHIBA XAIRO, Japan) the length and site of bifurcation of CCA was determined, posterior wall was exposed, and CIMT was measured. This device can measure the thickness by 0.1 mm.

Follow-up study

After the determination of initial laboratory and atherogenic parameters, all the patients were followed for 18 months. No patient was lost to follow-up. All the patients were follow-up by a nephrologist for at least

3 months. Each death was reviewed and assigned an underlying cause by three physicians. Cardiovascular outcome measure was recorded as stroke, acute myocardial infarction, and congestive heart failure. We divided all subjects into either expired and nonexpired groups and evaluated the influence of CIMT on the outcome.

Statistical analysis

Continuous variable are expressed as mean ± standard deviation and compared using one-way ANOVA in case of normally distributed data and Kruskal-Wallis test for nonnormal data. Categorical variable was compared using Chi-square test. Correlations between various kidney function parameters have been calculated using Pearson or Spearman correlation coefficient. Pearson's correlation coefficient was used to calculate the correlation between CIMT and other demographic and biochemical parameters. Regression analysis was carried out using CIMT as the dependent variable and other demographic and biochemical parameters as the independent variables. Receiver operator curve analysis has been done to calculate the area under the curve (AUC) for CIMT and identifying the optimal CIMT cut-off values for predicting mortality. Survival between the two groups was compared by the Kaplan-Meier method. Adjusted risk estimates for mortality were calculated using univariate and multivariate Cox proportional hazard regression models. Statistical significance was set at $P < 0.05$. All the analysis has been done using STATICA version 13 and MedCalc software (MedCalc Software bvba, Acacialaan 22 8400 Ostend Belgium).

Results

Characteristic of study subject

Of 88 CKD stage-V patients, 47 were male and 41 were female, and in 50 normal healthy controls, 27 (54.0%) were male, and 23 (46.0%) were female. Among these patients, 82% were taking angiotensin-converting enzyme inhibitors, 77% were on diuretics, 42% were on beta blockers and 42% were taking calcium channel blockers. The use of statins was observed in 34% of the patients, 32% were taking sevelamer, 5% were on calcitriol, and 5% were taking calcium carbonate. The aforementioned drugs were maintained during the follow-up period.

Mean age was 40.22 ± 12.31 years in controls, 39.54 ± 12.49 years in nonexpired group and 44.55 ± 15.11 in expired group ($P = 0.85$). Mean BMI was higher in controls in comparison to case ($P < 0.001$). Both systolic and diastolic blood pressure were higher in cases in comparison with control ($P < 0.001$). Estimated glomerular filtration rate was normal in control subject whereas markedly decreased in cases ($P < 0.001$). During the study, 88 patients received dialysis, two patients underwent renal transplantation, and 29 were expired in this period. There were 34 cardiovascular events like angina ($n = 14$), stroke ($n = 2$), acute myocardial infarction ($n = 13$), hypertensive emergency ($n = 2$), arrhythmia ($n = 1$), transient ischemic attack ($n = 1$), and heart failure ($n = 1$). The deaths were attributed due to acute myocardial infarction, congestive heart failure, and stroke. Mean CIMT was higher in expired group (1.02 ± 0.21) than in nonexpired group (0.92 ± 0.12) and (0.55 ± 0.06) in controls ($P < 0.001$) [Table 1].

Mean value of creatinine, calcium, serum phosphorus, serum calcium-phosphorus product and 24 h urine protein were higher in expired and nonexpired group in comparison to healthy control group. This difference was statistically significant ($P < 0.01$, $P < 0.001$) [Table 2].

Correlation of carotid intima-media thickness with cardiovascular risk factors

Correlation of CIMT with different variables was analyzed in controls and hemodialysis group. Significant positive correlation was found with age ($r = 0.327$, $P < 0.001$), blood urea ($r = 0.423$, $P < 0.001$), serum

Table 1: Demographic profile of the study subjects

Parameters	Control ($n = 50$) (mean ± SD)	Nonexpired ($n = 59$) (mean ± SD)	Expired ($n = 29$) (mean ± SD)	*P*
Gender				
Male	27 (54.0)	32 (54.24)	15 (51.72)	0.973
Female	23 (46.0)	27 (45.76)	64 (46.38)	
Age (years)	40.22±12.31	39.54±12.49	44.55±15.11	0.85
BMI (kg/m^2)	22.59±1.71	19.15±1.97	19.14±1.88	<0.001
SBP (mmHg)	120.72±7.79	164.98±11.66	165.79±12.22	<0.001
DBP (mmHg)	64.60±5.86	93.83±8.11	94.41±8.13	<0.001
eGFR (mL/min)	114.17±20.57	9.30±2.89	7.17±3.22	<0.001
CIMT (mm)	0.55±0.06	0.92±0.12	1.02±0.21	<0.001

SBP = Systolic blood pressure, BMI = Body mass index, DBP = Diastolic blood pressure, CIMT = Carotid intima-media thickness, eGFR = Estimated glomerular filtration rate, SD = Standard deviation

Table 2: Biochemical profile of the study subjects

Parameters	Control (n = 50) (mean ± SD)	Nonexpired (n = 59) (mean ± SD)	Expired (n = 29) (mean ± SD)	P
Serum creatinine (mg%)	0.78±0.18	6.95±1.85	8.96±3.62	<0.001
Serum calcium++ (mg%)	8.44±0.69	7.29±1.19	7.28±1.52	<0.01
Serum phosphorus−− (mg%)	2.96±0.46	8.95±3.15	9.19±2.90	<0.001
Serum calcium × serum phosphorus	25.0±4.58	63.08±20.65	68.46±29.03	<0.05
Hemoglobin (g%)	11.36±2.21	7.55±1.66	7.85±2.24	<0.001
LDL (mg%)	69.09±58.36	116.27±64.13	111.79±30.39	<0.001
HDL (mg%)	41.24±7.79	36.17±10.34	32.81±10.02	<0.01
TG (mg%)	92.42±19.93	151.65±112.24	149.88±39.79	<0.01
TC (mg%)	168.05±52.11	163.96±69.80	165.48±53.14	<0.01
Serum albumin (mg%)	4.25±0.28	3.30±0.42	3.35±0.56	<0.001
24 h urine protein (mg%)	135.12±21.07	1850.41±2346.61	1908.10±1344.04	<0.001
Serum uric acid (mg%)	5.77±0.98	9.35±3.06	10.16±1.92	<0.001

LDL = Low-density lipoprotein, HDL = High-density lipoprotein, TG = Triglyceride, TC = Total cholesterol, SD = Standard deviation

creatinine (r = 0.684, P < 0.001), serum triglyceride (r = 0.397, P < 0.001), high-density lipoprotein (HDL) (r = 0.389, P < 0.01), total cholesterol (r = 0.463, P < 0.01), LDL (r = 0.324, P < 0.001), corrected calcium (r = 0.383, P < 0.001), serum phosphorus (r = 0.482, P < 0.001), serum calcium phosphorus product (r = 0.364, P < 0.001), serum Mg^{++} (r = 0.362, P < 0.001), serum uric acid (r = 0.383, P < 0.001), 24 h urine protein (r = 0.268, P < 0.001), systolic blood pressure (r = 0.342, P < 0.001), diastolic blood pressure (r = 0.343, P < 0.001), and BMI (r = 0.374, P < 0.001). Negative correlation was found with estimated glomerular filtration rate (r = −0.15, P < 0.001) [Table 3].

Regression analysis performed using CIMT as the dependent variable in a multiple regression model including covariate reported in univariate analysis. The associations with age (β = 0.34, P < 0.01), albumin (β = 0.35, P < 0.01) and serum calcium phosphorus product (β = 0.32, P < 0.01) were found to be statistically significant in the analysis [Table 4].

Impact of carotid intima-media thickness

Univariate cox proportional regression analysis revealed that various factors such as age, the product of calcium and phosphorus, albumin, and CIMT were associated with all-cause mortality. Multivariate regression analysis demonstrated that albumin and CIMT became significant independent predictors of all-cause mortality. Adjusted hazards ratios of all cause and cardiovascular mortality for an increase of 0.1 mm in CIMT was 1.16 (95% confidence interval [CI]: 0.15-9.09) [Table 5]. 0.1 mm increment of CIMT also increased the risk of cardiovascular mortality by 16% (95% CI: 0.15-9.09) in patients who have otherwise no history of any cardiovascular events [Tables 5 and 6]. The AUC for CIMT was 0.725 (95% CI: 0.619-0.815). A CIMT cut-off of 0.97 had a sensitivity of 88.97% and specificity of 72.88% in predicting the mortality. The +likelihood ratio (LR) value of 2.54 (95% CI 1.6-4.1) and -LR value of 0.43 (95% CI 0.2-0.7) [Figure 1].

Table 3: Correlation of CIMT with different variables in control group (n = 50) and hemodialysis group (n = 88)

Parameters	Control group		Hemodialysis group	
	r	P	r	P
Age	0.33	0.054	0.327	<0.001
GFR	−0.15	0.688	−0.15	0.001
Serum urea	−0.13	0.730	0.423	<0.001
Serum creatinine	0.17	0.343	0.684	<0.001
Serum TG	0.15	0.331	0.397	<0.001
HDL	0.13	0.298	0.389	<0.01
LDL	−0.21	0.212	0.324	0.001
TC	−0.13	0.320	0.463	<0.01
Corrected calcium	0.01	0.483	0.383	<0.001
Serum phosphorus	0.23	0.432	0.482	<0.0010
Serum calcium phosphorus product	0.23	0.353	0.364	<0.0010
Serum magnesium	0.24	0.504	0.362	<0.001
Serum uric acid	−0.13	0.727	0.383	<0.001
24 h urine protein	−0.17	0.647	0.268	<0.001
Serum albumin	0.21	0.567	0.20	<0.01
SBP	0.09	0.799	0.342	<0.001
DBP	−0.29	0.411	0.343	<0.001
BMI	0.13	0.718	0.374	>0.001

CIMT = Carotid intima-media thickness, BMI = Body mass index, GFR = Glomerular filtration rate, SBP = Systolic blood pressure, DBP = Diastolic blood pressure, TG = Triglyceride, LDL = Low-density lipoprotein, HDL = High-density lipoprotein, TC = Total cholesterol

Kaplan-Meier survival curve shows CIMT to be closely associated with the renal end point in CKDs patient. Based on the cut-off value of CIMT at 0.97 mm, patients with value <0.97 mm had a renal survival rate of 73.4% while patients with greater than cut-off value of CIMT had a renal survival rate of 16.5% [Figure 2].

Table 4: Multiple regression analysis of CIMT (expiry and nonexpiry subjects)

Parameter	β coeff.	P
Age	0.34	<0.01
SBP	−0.16	0.14
DBP	0.17	0.12
eGFR	−0.18	0.58
Serum uric acid	0.05	0.68
24 h urine protein	−0.12	0.28
Serum albumin	0.35	<0.01
Serum calcium++	0.11	0.31
Serum phosphorus−−	0.12	0.26
Serum calcium × serum phosphorus	0.32	<0.01
TG	−0.10	0.35
LDL	−0.02	0.83
HDL	−0.01	0.93
Blood urea	0.08	0.44
Serum creatinine	0.28	0.52

β is the standardized coefficient, SBP = Systolic blood pressure, DBP= Diastolic blood pressure, eGFR = Estimated glomerular filtration rate, SD = Standard deviation, TG = Triglyceride, LDL = Low density lipoprotein, HDL = High density lipoprotein, CIMT = Carotid intima-media thickness

Table 5: Univariate cox proportional hazard model

Parameter	Units of increase	HR	95% CI
Age (years)	1	1.03	1.003-1.06
Calcium × phosphorus (mg^2/dL^2)	1	1.008	0.99-1.022
Albumin (mg%) (g/dL)	1	1.02	0.56-2.65
CIMT (mm)	0.1	1.17	0.16-9.56

HR = Hazard ratio, CI = Confidence interval, CIMT = Carotid intima-media thickness

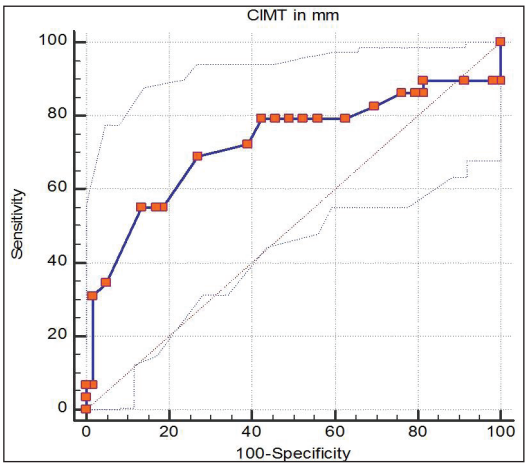

Figure 1: Receiver operator curve for carotid intima-media thickness (CIMT) considering mortality as a status variable. The area under curve for CIMT was 0.725 (95% confidence interval [CI]: 0.619-0.815). A CIMT cut-off of 0.97 (unit required) had a sensitivity of 88.97% and specificity of 72.88% in predicting the mortality. The +likelihood ratio (LR) value of 2.54 (95% CI 1.6-4.1) and -LR value of 0.43 (95% CI 0.2-0.7)

Discussion

Hemodialysis patients are highly prone to CVD, which accounts for roughly half of the mortality in these patients. Atherosclerosis is the most common cause of cardiovascular morbidity in ESRD patients. In healthy middle-aged adults, CIMT values between 0.6 and 0.7 mm have been considered normal, while CIMT of 1 mm or more has been associated with significant risk of coronary heart diseases.[18] In healthy Indian adults, the average and maximum CIMT values reported were 0.67 and 0.70 mm, respectively.[19] The measurement of CIMT varies with age and values >1.0 mm are considered abnormal in younger population and confer increased absolute risk of coronary heart disease.[20,21] In our study, mean value of CIMT in expired group was higher (1.02 ± 0.21 mm) as compared to nonexpired group on hemodialysis (0.92 ± 0.12 mm). This showed that expired group was much prone to atherosclerosis in comparison with nonexpired group.

Recently, increased CIMT is reported as an independent predictor of cardiovascular events and mortality in

Table 6: Multivariate cox proportional hazard model

Parameter	Units of increase	HR	95% CI
Age (years)	1	1.004	0.98-1.03
Calcium × phosphorus (mg^2/dL^2)	1	1.001	0.99-1.01
Albumin (mg%) (g/dL)	1	1.06	0.56-2.01
CIMT (mm)	0.1	1.16	0.15-9.09

HR = Hazard ratio, CI = Confidence interval, CIMT = Carotid intima-media thickness

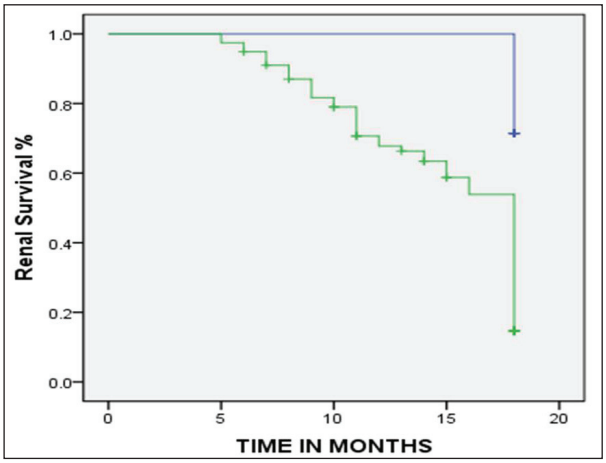

Figure 2: Kaplan-Meier survival curve shows carotid intima-media thickness (CIMT) to be closely associated with the renal end point in chronic kidney disease patients. Based on the cut-off value of CIMT at of 0.97mm, patients with value <0.97 mm had a renal survival rate of 73.4% while patients with CIMT greater than cut-off value of CIMT had a renal survival rate of 16.5%.

dialysis patients.[22,23] Our study result showed that a mean CIMT of 0.92 ± 0.12 mm in a group of alive hemodialysis patients, which was significantly higher than in an age- and sex-matched control group, but in expired hemodialysis patients mean CIMT was still higher 1.02 ± 0.21 mm than alive hemodialysis patients. These results are in accordance with other authors.[24,25] Increased carotid artery IMT is considered as a marker of early atherosclerotic changes.[26] As per several studies, known traditional risk factors such as increasing age, hypercholesterolemia, hypertension, deranged fasting blood sugar, and smoking were also implicated as a risk factor for atherosclerosis in CKD.[27]

In our study, 0.1 mm increment of CIMT also increased the risk of cardiovascular mortality by 16% (95% CI 0.15-9.09) in patients without a prior history of cardiovascular events. With compatible to our study Benedetto *et al*.[14] first demonstrated that a 0.1 mm increment of CIMT predicted a 24% higher risk for cardiovascular mortality in end-stage renal failure patients on hemodialysis or peritoneal dialysis during a follow-up period of 30 months. Recently, Nishizawa *et al*.[15] reported that increased CIMT became an independent predictor of 30-month cardiovascular death.

Atherosclerotic changes in carotid arteries are assumed to be indicative of atherosclerosis throughout the body and peripheral arteries.[14,22,23] We also found that expired subjects had an increased CIMT in nondiabetics or nonsmoking patients, and associated with poor prognosis in nondiabetic subjects. These findings convincingly suggested that assessment of CIMT is useful in predicting future mortality in uremic patients.

Our study showed a significant correlation between CIMT and age ($r = 0.327$, $P < 0.001$), which is in concordance with other studies and indicates the natural progression of atherosclerosis with increasing age. Increasing trend of CIMT with age has been also reported by other authors.[28,29]

Our study result showed the positive correlation between CIMT and other risk factors such as systolic and diastolic blood pressure, LDL and HDL levels, blood urea, serum creatinine, serum calcium, serum phosphorus, and serum uric acid. Our result were compatible with a study done by Briese *et al*.[30] There was a trend for higher CIMT value in an expired group than nonexpired group dialysis patients. These findings emphasized the relationship between traditional cardiovascular risk factors and CIMT, which have been shown to be a predictor of CVD in many studies done previously.

In our study, however, univariate regression analysis failed to show any significant association between CIMT and mortality, but in multiple regression model including covariate reported using univariate analysis.

The associations with age ($\beta = 0.34$, $P < 0.01$), serum albumin ($\beta = 0.35$, $P < 0.01$), and serum calcium-phosphorus product ($\beta = 0.32$, $P < 0.01$) were found to be statistically significant in the analysis. These finding was compatible with a study done by Kato *et al*.[16] Kaplan-Meier survival curve shows CIMT to be closely associated with the renal end point in CKD patients. Based on the cut-off value of CIMT at of 0.97 mm, patients with value <0.97 mm had a renal survival rate of 73.4% while patients with greater than cut-off value of CIMT had a renal survival rate of 16.5%. In our study, cardiovascular mortality was 32.9%. Study done by other authors showed that a 0.1 mm increment of CIMT was associated with increased risk of cardiovascular mortality by 39% (95% CI, 1.11-1.75) in patients without a previous history of cardiovascular accidents.[16]

Although it is clear that CIMT is a good predictor of subsequent mortality in hemodialysis patients. There are some limitations in our study:

1. Premature atherosclerosis, serum homocysteine, lipoprotein (a), obesity, physical activity, atherogenic diet, proinflammatory factors, and prothrombotic factors could not be included due to the limitations of budget and study design.
2. Small number of participants.

Conclusion

Various risk factors have been correlated to CIMT value in different studies, with some conflicting results. In the present study, we found a significant relationship between CIMT and serum calcium, phosphorus. Among the various described risk factors, we found a significant relationship between CIMT with age and serum cholesterol level. Therefore, it seems that the traditional risk factors for CVD in the normal population also affect the value of CIMT in dialysis and that uremia is an additive risk factor in those subjects who had raised CIMT. Thus, we propose cohort studies in different group of CKD patients on hemodialysis and form convincing association between CIMT and cardiovascular risk.

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