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EVALUATION OF OXIDATIVE STRESS AND ANTI OXIDANT STATUS IN CHRONIC KIDNEY DISEASE

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ABSTRACT

Background: Chronic Kidney Disease (CKD) is a progressive condition characterized by a gradual loss of renal function, often associated with increased oxidative stress and impaired antioxidant defence. Oxidative stress plays a critical role in the pathophysiology and progression of CKD and its complications, particularly cardiovascular disease.

Objective: To estimate the concentrations of MDA (Malondialdehyde), a product of lipid peroxidation and to describe their relationship with several pathophysiologic processes in cases of chronic kidney disease and their possible therapeutic implications, in improving the renal parameters.

Methods: A case-control study was conducted involving CKD patients at various stages and age-matched healthy controls. Blood samples were analysed for markers of oxidative stress, including malondialdehyde (MDA), and Vitamin C, Lipid profile, blood urea and Serum creatinine. Serum creatinine and estimated glomerular filtration rate (eGFR) were used to assess kidney function.

Results: CKD patients exhibited significantly elevated levels of MDA, indicating increased lipid peroxidation, and a marked decrease in antioxidant enzyme activities compared to controls.

Conclusion: CRF have increased levels of oxidative stress markers and decreased antioxidant levels. The degree of oxidative stress is related to endothelial dysfunction. These factors may be important with respect to the high morbidity and mortality of CVD found in patients with CRF. Using oxidative stress biomarkers in a panel of biomarkers of processes known to impact on CKD development may allow early detection.

Keywords: CKD (chronic kidney disease), Oxidative stress, C-reactive protein (CRP), Hemodialysis.

INTRODUCTION:

Chronic Kidney Disease is a progressive loss of kidney function over a period of months or years through five stages. It is a significant public health problem with an increasing incidence, prevalence, poor outcomes and high cost. It is characterized by lower glomerular filtration rate and associated metabolic consequences. Hemodialysis is the mainstay of management of these patients before kidney transplant1. It is usually associated with enhanced oxidative stress, but scarce reports exist on the status of oxidative stress in these patients before hemodialysis[1].

The possible causes of oxidative stress in chronic kidney disease include the activation of neutrophils, macrophages, vascular cells, various glomerular cells and complement activation, iron overload, increase of advanced glycation end-points and increased homocysteine[2,3,4].

The removal during dialysis of antioxidant hydro-soluble factors (i.e., Urea, vitamin C, etc.) has been implicated as the cause of oxidative stress in dialyzed Chronic Kidney Failure patients. High free radical load contributes to the pathogenesis of

ischemia-reperfusion injury in the kidney[5] and plays a role in a variety of kidney diseases such as glomerulo nephritis and tubulointerstitial nephritis that progresses to end-stage renal failure[6].

Accumulating evidence suggests that chronic kidney disease (CKD) is associated with enhanced oxidative stress[7]. The targets of oxidative stress in CKD patients are muscle fat and proteins, thus contributing to the skeletal muscle disease in the patients. Endothelial dysfunction and atherogenesis are possible consequences of oxidative stress in CKD patients[8].Following kidney injury, glomerular filtration of albumin is increased, and the re- absorption and degradation of albumin by tubules is decreased, resulting in increased levels of intact albumin in the urine[9].

C-reactive protein (CRP) production is part of the non-specific acute-phase response to most forms of inflammation, infection and tissue damage[10]. It is a marker of inflammation[11] and has emerged as a reliable independent risk marker for CKD patients[12]. The potential causes of chronic inflammation in CKD patients include reduced renal clearance or increased production of pro-inflammatory cytokines[13], or reduced renal clearance of advanced glycation end products[14], or atherosclerosis process, chronic heart failure, inflammatory diseases and infections[15, 16].

Several pieces of evidence available link oxidative stress, cardiovascular diseases, and renal damage. Others elucidate the causes of oxidative stress after hemodialysis, but less number of reports exist on the status of oxidative stress in chronic kidney failure patients before hemodialysis. To bridge this gap in knowledge, the present study was designed to determine the plasma levels of MDA, Vitamin C, urea and creatinine in CKD patients.

AIMS & OBJECTIVES

1. To estimate the concentrations of serum creatinine and blood urea in patients with CKD.
2. To evaluate the levels of serum creatinine and blood urea in healthy controls.
3. To describe the importance of antioxidant Vitamin C, that work in human cells against toxic reactive oxygen species (oxidative stress) in patients with CKD and healthy controls.
4. To estimate the concentrations of MDA (Malondialdehyde), a product of lipid peroxidation.
5. To describe their relationship with several pathophysiologic processes in cases of chronic kidney disease and their possible therapeutic implications, in improving the renal parameters.
6. To study lipid profile, as patients with CKD have an increased risk of cardiovascular disease.

Methodology:

Clinically diagnosed cases of CKD attending nephrology department of King George Hospital attached to Andhra Medical College, Visakhapatnam were selected. Healthy controls were selected from regular blood donors in the blood bank, King George Hospital and written informed consent was taken from each subject. The cases and healthy controls voluntarily participated in the study.

Subjects:

A total number of 150 subjects participated in the study of which **Group 1** consisted of 100 subjects who were CKD patients; **Group 2** include 50 subjects who were age and sex-matched healthy controls.

Inclusion criteria:

1. Clinically diagnosed cases of CRF in the age group between 35-60 years who were on medical treatment.
2. An equal number of age and sex-matched healthy controls.

Exclusion criteria: The following patients were excluded from the study. Patients with:

1. Those taking medicines with antioxidants
2. Liver diseases
3. Infectious diseases
4. Immune complex diseases
5. Malignancies

a) **Sample collection:**
Under aseptic precautions, about 5 ml of blood was collected in a sterile vacutainer from selected CRF patients on medical treatment. Serum was separated by centrifugation and used for analysis of the following parameters.

b) **Parameters:**
Serum was used for estimating the following parameters

- Estimation of serum lipid peroxidation product--Malondialdehyde- Method of DRAPER AND HADLEY
- Estimation of serum Vitamin C (Ascorbate)--- Method of Aye Kyaw, (1978)

- Blood urea by Modified Berthelot Method
- Serum Creatinine by Jaffe's method
- Serum Cholesterol (CHOD/POD Method)
- Serum Triglycerides (GPO /POD ESPAS, 1973)
- Serum HDL Cholesterol (Phosphotungstate-CHOD-POD)
- Serum LDL AND VLDL - By Calculation (FRIEDWALD W.T.,1972)
  All the reagents used in the estimation were of analytical grade.

Methods of Statistical Analysis: Descriptive data were presented as percentages and continuous data was presented as mean, SD and range values. Student's unpaired, 't'-test was used for comparing the means of two groups (cases& controls). The relationship between measurements was assessed by Karl Pearson's coefficient of correlation. Data were entered into Microsoft Excel and analyzed in SPSS 20 package. For all the tests, **a p-value of 0.05 or less** was considered as statistical significance. Study was conducted after getting approval from Institutional ethics committee of Andhra Medical College, Visakhapatnam.

RESULTS:

A total number of 150 subjects were considered in the study. The subjects include 100 cases (GROUP 1) and 50 healthy controls (GROUP 2). The cases were patients with chronic kidney disease. The subjects were analyzed for following parameters viz. Vitamin C, MDA levels, Serum Creatinine, blood urea and Lipid profile. The subjects are predominantly in the age group of 35 to 55years in both the cases and controls. The mean age of the cases and controls is 49.66 and 48.08 years respectively.
The study showed a male preponderance in both cases and controls. The mean concentration of serum creatinine was in the range of 1.03$\pm$ 0.13mg/dL in controls and 7.116$\pm$2.78mg/dL in cases. Statistical analysis by unpaired t-test showed that the mean value of serum creatinine was increased in cases when compared to controls and was statistically significant ($p<0.001$). The blood Urea values were predominantly in the range of 80 to 100 mg/dL in GROUP 1.

The mean concentration of blood urea was in the range of 29.4$\pm$2.95 mg/dL in controls and 93.14$\pm$21.54mg/dL in cases. Statistical analysis by unpaired t-test showed that the mean value of blood urea was increased in cases when compared to controls and was statistically significant ($p<0.001$).

Table:1 MDA LEVELS IN CASES AND CONTROLS

	Range (nmol/ml)	**Mean (nmol/ml)**	**SD**
Cases n=100	**5.0 – 7.5**	**6.014**	**0.606**
Controls n=50	**2.1 – 4.0**	**2.72**	**0.468**

t Value: 25.5 P value : < 0.001

In the present study, Mean values of Malondialdehyde among cases is 6.01 nmol/ml$\pm$ 0.61(Mean$\pm$ S.D) with the range of 5.0 to 7.5 nmol/ml and that of control is 2.72 nmol/ml $\pm$ 0.468 (Mean $\pm$ S.D) with the range of 2.1 to 4.0. The increase in the serum Malondialdehyde among cases is significant with a **'p'** value of <0.001.

TABLE 2: MALONDIALDEHYDE (MDA) LEVELS IN CHRONIC KIDNEY DISEASE PATIENTS (CKD)

Range nmol/ml	**No of Males**	**%**	**No of Females**	**%**	**Total**	**100**
5 – 5.9	28	28%	29	29%	57	57%
6 - 6.9	20	20%	17	17%	37	37%
> 7	4	4%	2	2%	6	6%
Total	52		48			100%

Total patients with Malondialdehyde level> 6 nmol/ml are forty-three (43) out of fifty (100) constituting 43 %. Males are twenty-four (24%), and females are nineteen (19%).

TABLE 3: MDA LEVELS AND LIPID PROFILE IN CASES AND CONTROLS

	Mean Values	**Mean Values**		
	Cases	**Controls**	**'t' Value**	**'p' Value**
MDA Levels (nmol/ml)	6.01	2.72	25.5	<0.001
LDL (mg/dl)	176.09	103.38	16.03	<0.001
Cholesterol (mg/dl)	246.7	156.86	18.8	<0.001
HDL (mg/dl)	32.96	38.46	4.8	<0.001

The table shows comparison of various parameters in cases and controls with Statistical significance.

TABLE 4: MDA LEVELS IN MALES AND FEMALE IN THE CASES AND CONTROLS

	MALES (Mean± SD)	**FEMALES** (Mean± SD)	**TOTAL** (Mean± SD)
CASES	6.07± 0.61	5.95± 0.61	6.01±0.61
CONTROLS	2.74± 0.47	2.90 ± 0.66	2.72± 0.46

The above table shows there is increase in Malondialdehyde level in both the male and female.

TABLE 5: SERUM CREATININE VALUES DISTRIBUTION IN CASES AND CONTROLS

CREATININE (C)(mg/dL)	**GROUP 1 (CASES)**	**GROUP (CONTROLS)**	**GROUP (1+2)**	**PERCENT (%)**
	FREQUENCY	**FREQUENCY**	**FREQUENCY**	
≤1.4	0	50	50	33.33
1.5-5	14	0	14	9.33
5-8	66	0	66	44
8-15	20	0	20	13.33
Total	100	50	150	100

The majority (66%) of cases had serum creatinine values between 5-8 mg/dL. Among controls 100%had creatinine less than 1.4mg/dL. This difference has been found to be statistically significant. (p value<0.001)

TABLE 6: BLOOD UREA VALUES DISTRIBUTION IN CASES AND CONTROLS

UREA(U) (mg/dL)	GROUP 1 (CASES)	GROUP 2 (CONTROLS)	GROUP (1+2)	PERCENT (%)
	FREQUENCY	FREQUENCY	FREQUENCY	
<40	0	50	50	33.33
40-80	26	0	26	17.33
81-100	46	0	46	30.66
>100	28	0	28	18.66
Total	100	50	150	100

Majority 46% of cases had blood urea values between 81-100 mg/dL. Among controls, 100% had blood urea levels less than 40mg/dL. This difference has been found to be statistically significant. (p value< 0.001).

Discussion:

Chronic kidney disease (CKD) is a devastating disease with clinical, economic and ethical dimensions and is emerging as a major public health problem globally[17]. Chronic renal failure (CRF) is the irreversible deterioration of renal function that gradually progresses to end-stage renal disease (ESRD)117. Once end-stage renal disease (ESRD) supervenes, renal replacement therapy in the form of chronic peritoneal or hemodialysis and transplantation is necessary[18].

Evidence suggests that chronic kidney disease is associated with enhanced oxidative stress, but not many reports exist on the status of oxidative stress in these patients before hemodialysis. The antioxidants which control the oxidative stress state represent a major line of defense regulating overall health[19]. The targets of oxidative stress in CKD patients are muscle fats and proteins, thus contributing to the skeletal muscle disease in the patients. Endothelial dysfunction and atherogenesis are pos sible consequences of oxidative stress in CKD patients.

Several shreds of evidence available link oxidative stress, cardiovascular diseases, and renal damage. Others elucidate the causes of oxidative stress, but scarce reports exist on the status of oxidative stress in chronic kidney failure patients before hemodialysis. To bridge this gap in knowledge, the present study was designed to determine the plasma levels of MDA, Vitamin C, urea, and creatinine in CKD patients.

The present study includes 150 subjects of which 100 were patients with chronic renal failure and 50 were normal healthy controls. The main aim of this study was to estimate the concentrations of blood urea, serum creatinine concentrations, MDA levels and Vitamin C and Lipid profile to understand their correlations if any.

CREATININE

The mean concentration of serum creatinine was in the range of 1.03 ± 0.13mg/dL in controls and 7.12 ± 2.78 in cases. Statistical analysis by unpaired t-test showed that the mean value of serum creatinine was increased in cases when compared to controls and was statistically significant ($p<0.001$). In the present study chi-square test has shown that majority (66%) of cases had serum creatinine values between 5-8 mg/dL. Among controls, all (100%) had creatinine less than 1.4mg/dL. A statistically significant difference has been found between cases and controls (p value<0.001). Furthermore, 14% of cases had serum creatinine value between 1.5-5 mg/dL and 20% of the cases had serum creatinine value between 8-15 mg/dL.

UREA

The mean concentration of **blood urea** was in the range of 93.14 ± 21.54mg/dL in cases and 29.4 ± 2.95 mg/dL in controls. Statistical analysis by unpaired t-test showed that the mean value of blood urea was increased in cases when compared to controls and was statistically significant ($p<0.001$). In the present study chi-square test has shown that majority (46%) of cases had blood urea values between 81-100 mg/dL. Among controls, all (100%) had blood urea levels less than 40mg/dL.

A statistically significant difference has been found between cases and controls (p value<0.001). Furthermore, 26% of cases had blood urea value between 40-80 mg/dL and 28% of the cases had blood urea value above 100 mg/dL. CRF is characterized by a gradual decrease in nephron number and function. Decrease in the concentrating ability of kidney leads to accumulation of urea and creatinine.[20]

VITAMIN C

Vitamin C was estimated in 50 controls, and their levels were noted that majority of them (41 subjects) are in the range of 0 .20 to 0.40 mg/dl & 9 subjects are in the range of 0.1-0.19 mg/dl.Out of 100 cases, majority of them (81 cases) are in the range of 0.1-0.19 mg/dl, and 19 cases with < 0.09 mg/dl and none were in the range of 0.2-0.4 mg/dl.The Values of present study are in consistent with the study by Mehdi, W.A. (2011)[22].

The possible sources of increased oxidative stress might include increased generation of free radicals or an impaired antioxidants defense system. Oxygen free radicals are toxic to tissue because of their high reactivity, and ability to form covalent bonds non enzymatically. Extensive studies with biological materials have shown clearly that reactive free radicals can produce chemical modifications in cells and damage the proteins lipids, carbohydrates and nucleotides. To overcome these consequences, cells have antioxidant defense systems, which scavenge the free oxygen radicals and suppress the free radical chain and lipid peroxidation [21].

Oxidative stress, the state in which an imbalance between the levels of reactive oxygen species and antioxidants exists, can lead to disturbed glucose metabolism and hyperglycemia. Oxidative stress is consistently observed in patients with renal fail ure, and the degree of oxidative stress tends to be greater in those with diabetic nephropathy and more diabetic complications. Various studies have reported protective effects of antioxidants against oxidative damage of kidney. The level of vitamin C i n plasma and renal tissue is significantly reduced in CKD patients. Impaired antioxidant functions also play a role in development of chronic kidney disease. Vitamin C is one of the most important antioxidants that inhibits lipid peroxidation and improves endothelial function. In one study, it is proposed that every other day supplementation with 250 mg vitamin C for 12 weeks increases serum vitamin C, decreases MDA levels, and improves lipid profiles in hemodialysis patients.

MDA

Mean Blood Malondialdehyde levels are (6.014±0.61nmol/ml) elevated in the cases compared to controls (2.72±0.46 nmol/ml). A significant difference was observed in mean MDA changes between cases and control groups. Total patients with Malondialdehyde level> 6 nmol/ml are forty-three (43) out of fifty (100) constituting 43 %. Males are twenty-four (24%), and females are nineteen (19%). A statistically significant difference has been found between cases and controls (p value<0.001). A study by Bhatia et al. [23] showed that the MDA and SOD levels were found significantly increased in DN patients as compared to DM patients.

Malondialdehyde (MDA) is an end-product generated by lipid peroxidation and has been used to demonstrate increased oxidative stress during CKD.

The rise in serum MDA indicated that any oxidative stress incurred sufficiently could cause free radical mediated peroxidation of lipid component in cell membrane, thus MDA is a good indicator for evaluating oxidative stress in degenerative disease like CKD and diabetes mellitus. The increased oxidative stress levels that observed in CKD patient are consistent with the finding of several previous studies.[24]

In the present study, the mean MDA Values of cases 6.014 ± 0.61nmol/ml whereas in controls it was 2.72 ± 0.46 nmol/ml. In Raju et al[25] study done in 2013, the mean MDA Values of cases 6.16 ± 0.85nmol/ml whereas in controls it was 2.96 ± 0.51nmol/ml. In Kachhawa et al[26] study done in 2014, the mean MDA Values of cases 3.9±0.4 nmol/ml whereas in controls it was 1.5±0.2 nmol/ml. The Values of present study are in consistent with the above studies. The values of Kachhawa et al represented the values estimated in CKD patients without hypertension.

LIPID PROFILE

The mean concentration of total cholesterol was in the range of 246.7± 22.6 mg/dL in cases and 156.86 ± 20.65 mg/dL in controls and the mean concentration of HDL cholesterol was in the range of 32 ± 3.97 mg/dL in cases and 38.46 ± 4.51 mg/dL in controls. The mean concentration of LDL cholesterol was in the range of 176.1 ± 23.77 mg/dL in cases and 103.38 ± 17.81 mg/dL in controls and the mean concentration of VLDL cholesterol was in the range of 37.65 ± 5.6 mg/dL in cases and 28.3 ± 2.07 mg/dL in controls. The mean concentration of Triglycerides was in the range of 188.26 ± 28.44 mg/dL in cases and 141.76 ± 10.12 mg/dL in controls. The elevated levels of LDL cholesterol may provide increased substrates for reactive oxygen species. These free radicals react with the low-density lipoprotein (LDL), leading to the formation of oxidized LDL particles, which are important in the initiation and progression of atherosclerotic plaques because they can elicit inflammatory processes and lipid accumulation within the arterial wall. Patients with CKD generally have reduced plasma HDL cholesterol concentrations compared with nonuremic individuals.

Conclusion:

CRF have increased levels of oxidative stress markers and decreased antioxidant levels. The degree of oxidative stress is related to endothelial dysfunction. These factors may be important with respect to the high morbidity and mortality of CVD

found in patients with CRF. Using oxidative stress biomarkers in a panel of biomarkers of processes known to impact on CKD development may allow early detection.

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