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Comparative evaluation of electrolytes, glucose, protein, creatinine, urea and oxidative stress in male acute renal failure

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ABSTRACT

Acute renal failure is characterized by an abrupt decline in renal function resulting in an inability to excrete metabolic wastes and maintain proper fluid and electrolyte balance. The present study was undertaken to evaluate the serum electrolytes, glucose, protein, creatinine, urea, antioxidant enzymes and oxidant products in male acute renal failure patients. For the present study, 46 subjects of male acute renal failure aged 30 – 80 in year and 60 ages matched male healthy control were assessed. A Significant ($P<0.001$) increase serum potassium, creatinine, urea, and plasma malondialdehyde levels were found in male acute renal failure group while serum sodium, protein, and antioxidant enzymes were found to be decreased significantly ($P<0.001$) when compared to male healthy control group. This review will also discuss diagnostic tools, strategies for improved design of clinical trials, and other therapeutic interventions that will be needed to properly treat acute renal failure in the 21st century.

Key words: Acute renal failure, Serum electrolytes, superoxide.

INTRODUCTION

Generation of superoxide may occur at several cellular loci. In addition to mito-chondrial electron transport chain, superoxide is also produced by a variety of enzymatic processes such as the NAD(P)H oxidase, xanthine oxidase / dehydrogenase and aldehyde oxidase and by non-enzymatic processes such as the auto-oxidation of thiols and catecholamines. The plasma membrane is a rich source of reactive oxygen intermediates[1]. The production of free radicals can cause renal injury and play a role in pathogenesis of acute renal failure[2]. The development of acute renal failure in the hospital setting continues to be associated with poor outcomes[3–5]. Over the last three decades, several experimental models have identified pathophysiologic mechanisms associated with ARF and have enhanced our understanding of the disease[6–8]. It is evident that ARF can result from alterations in renal perfusion, changes in glomerular filtration, and tubular dysfunction, and that correction of these factors can ameliorate the effects of ARF[9-10]. It is well recognized that uncomplicated ARF can usually be managed outside the intensive care unit setting and carries a good prognosis with mortality rates less than 5 to 10 per cent[11, 12]. In contrast, ARF complicating nonrenal organ system failure in the intensive care unit setting is associated with mortality rates of 50 to 70 per cent, which has not changed for several decades.[13, 14].

There are also differences in the causes of acute renal failure in each study and lack of conformity in the use of the term “acute tubular necrosis”. Acute tubular necrosis is a pathological diagnosis, and patients with ischemic or toxic insults to their kidneys might be expected to have tubular

necrosis, but patients with acute renal failure due to other causes might not[15-17]. Acute renal failure can result from decreased renal perfusion without cellular injury; an ischemic, toxic, or obstructive insult to the renal tubule; a tubulointerstitial process with inflammation and edema; or a primary reduction in the filtering capacity of the glomerulus.

Smoking was associated prospective with increased risk for acute renal failure in the elderly[18]. Acute renal failure due to rhabdomyolysis from substance misuse is increasing in human being. Alcohol is frequently responsible[19, 20]. Smoking may also injure the kidneys by damaging the renal microvascular through oxidative stress, reduced nitric oxide generation, and increased plasma endothelin concentration. Smoking-induced cell dysfunction may further contribute to tubulointerstitial injury[21, 22].

MATERIAL AND MATHODS

The clinical material for present study comprised 46 patients of male acute renal failure admitted in medicine ward M. Y. Hospital, M. G. M. Medical College, Indore (M. P.), India and 60 ages matched male healthy control groups. The age range was taken from 30 to 80 years. Blood samples were collected from the patients at the time of admission as well as from individuals of male healthy control group. Clinical investigations were performed in the Department of Medical Biochemistry, M. G. M. Medical College, Indore (M. P.), India. Serum protein (Total), creatinine, urea, and superoxide dismutase were estimated by biuret, jaffe's, diacetyl monoxime, and misra H P et al methods respectively. Plasma malondialdehyde and haemolysate glutathione reductase, glutathione peroxidase, and catalase, were estimated by Jean C D et al method (1983), Horn H D (1963), Hafeman D G method (1974), and Asror K sinha method (1972) respectively. Serum electrolytes were estimated by end-point kit method. Obtained data were analyzed statistically by using student "t" test.

RESULTS

1. We observed, highly significant ($p<0.001$) increased biochemical values in the form of serum potassium ions, creatinine, urea, and plasma malondialdehyde when compared to male healthy control groups (Table No. 1 and 2).

Table 1: Comparative study of biochemical parameters between male healthy control and male acute renal failure (30 – 50 year)

S. No.	Particulars	Male control (30) Mean ± S. D.	Acute renal failure (24) Mean ± S. D.	t-test	P-value
Electrolyte					
1	Serum Sodium ions (mEq / L)	140.48 ± 1.30	128.5 ± 2.78	20.948	< 0.001
2	Serum Potassium ions (mEq / L)	4.44 ± 0.36	6.13 ± 0.19	20.774	< 0.001
Biochemical Parameters					
3	Serum Glucose (mg / dl)	89.55 ± 2.81	117.46 ± 3.62	31.911	< 0.001
4	Serum Protein (Total) (gm / dl)	7.17 ± 0.30	6.38 ± 0.16	11.631	< 0.001
5	Serum Creatinine (mg / dl)	0.89 ± 0.07	3.23 ± 0.50	25.384	< 0.001
6	Serum Urea (mg / dl)	27.71 ± 2.89	45.58 ± 2.02	25.668	< 0.001
Antioxidant / Oxidant product					
7	S-Superoxide dismutase (EU / mg protein / ml)	13.38 ± 1.05	9.77 ± 0.14	16.694	< 0.001
8	Glutathione reductase (EU / gm protein)	19.95 ± 0.16	17.61 ± 0.13	57.934	< 0.001
9	Glutathione peroxidase (EU / mg Hb%)	9.86 ± 0.15	7.1 ± 0.05	86.248	< 0.001
10	Catalase (EU / mg protein / ml)	5.85 ± 0.15	4.23 ± 0.09	46.575	< 0.001
11	Plasma Malondialdehyde (nano mole / ml)	3.47 ± 0.48	9.9 ± 0.37	54.001	< 0.001

2. Other biochemical markers such as serum sodium ions, protein (Total), superoxide dismutase, and haemolysate glutathione reductase, glutathione peroxidase, and catalase were decreased highly significantly ($p<0.001$) in male acute renal failure when

Table 2: Comparative study of biochemical parameters between male healthy control and male acute renal failure (51 - 80 year

S. No.	Particulars	Male control (30) Mean ± S. D.	Acute renal failure (22) Mean ± S. D.	t-test	P-value
Electrolyte					
1	Serum Sodium ions (mEq / L)	142.46 ± 1.35	125.14 ± 2.82	29.426	< 0.001
2	Serum Potassium ions (mEq / L)	5.16 ± 0.25	6.52 ± 0.32	17.210	< 0.001
Biochemical Parameters					
3	Serum Glucose (mg / dl)	99.33 ± 3.46	118.64 ± 3.33	20.198	< 0.001
4	Serum Protein(Total) (gm / dl)	7.52 ± 0.40	6.29 ± 0.22	13.028	< 0.001
5	Serum Creatinine (mg / dl)	0.94 ± 0.10	3.77 ± 0.51	29.725	< 0.001
6	Serum Urea (mg / dl)	35.42 ± 4.16	49 ± 2.09	14.041	< 0.001
Antioxidant / Oxidant product					
7	S-Superoxide dismutase (EU / mg protein / ml)	12.62 ± 1.70	8.94 ± 0.40	9.929	< 0.001
8	Glutathione reductase (EU / gm protein)	19.29 ± 0.12	17.34 ± 0.10	62.008	< 0.001
9	Glutathione peroxidase (EU / mg Hb%)	9.25 ± 0.09	5.9 ± 0.07	145.201	< 0.001
10	Catalase (EU / mg protein / ml)	5.24 ± 0.09	3.8 ± 0.06	65.101	< 0.001
11	Plasma Malondialdehyde (nano mole / ml)	3.69 ± 0.26	10.28 ± 0.32	81.880	< 0.001

Table 3: Comparative study of biochemical parameters between age groups (30 - 50 year) and (51 - 80 year) of male acute renal failure patients

S. No.	Particulars	Male control ($30\text{-}50^{Yr}$) Mean ± S. D.	Acute renal failure ($51\text{-}80^{Yr}$) Mean ± S. D.	t-test	P-value
Electrolyte					
1	Serum Sodium ions (mEq / L)	128.5 ± 2.78	125.14 ± 2.82	4.067	< 0.001
2	Serum Potassium ions (mEq / L)	6.13 ± 0.19	6.52 ± 0.32	5.077	< 0.001
Biochemical Parameters					
3	Serum Glucose (mg / dl)	117.46 ± 3.62	118.64 ± 3.33	1.147	0.257
4	Serum Protein (Total) (gm / dl)	6.38 ± 0.16	6.29 ± 0.22	1.596	0.118
5	Serum Creatinine (mg / dl)	3.23 ± 0.50	3.77 ± 0.51	3.624	< 0.001
6	Serum Urea (mg / dl)	45.58 ± 2.02	49 ± 2.09	5.642	< 0.001
Antioxidant / Oxidant product					
7	S-Superoxide dismutase (EU / mg protein / ml)	9.77 ± 0.14	8.94 ± 0.40	9.555	< 0.001
8	Glutathione reductase (EU / gm protein)	17.61 ± 0.13	17.34 ± 0.10	7.842	< 0.001
9	Glutathione peroxidase (EU / mg Hb%)	7.1 ± 0.05	5.9 ± 0.07	67.335	< 0.001
10	Catalase (EU / mg protein / ml)	4.23 ± 0.09	3.8 ± 0.06	18.883	< 0.001
11	Plasma Malondialdehyde (nano mole / ml)	9.9 ± 0.37	10.28 ± 0.32	3.710	< 0.001

compared to age matched male healthy control groups (Table No. 1 and 2).

3. Table number three showing comparison male acute renal failure between age 30 – 50 and 51 – 80 years. Levels of sodium ions, superoxide dismutase, glutathione reductase, glutathione peroxidase, and catalase were decreased highly significantly ($p<0.001$) between aged 51 to 80 years of male acute renal failure and also highly significantly ($p<0.001$) increased levels of potassium ions, creatinine, urea and plasma malondialdehyde were observed in age range 51 – 80 years of male acute renal failure.

DISCUSSION

Amongst several diseases, that affect the human these days, acute renal failure is considered the most dreaded. Acute renal failure is defined as the loss of renal function over a period of hours to days, as reflected in the glomerular filtration rate[23]. Acute renal failure is usually considered a disease of the hospitalized patients[24]. Hypekalemia in acute renal failure is usually caused by decreased elimination by the kidney[25]. Affects potassium excretion due to reduced nephron mass (number of functioning collecting ducts) and intrinsic impairment of active potassium secretion. Because the number of collecting ducts is directly related to the glomerular filtration rate, renal failure whether acute or chronic, leads to impaired renal potassium secretion[26]. Increased levels of blood urea nitrogen (urea) indicated the presence of reversible vasoconstriction, while uncontrolled accumulation of nitrogen waste products i.e. blood urea and serum creatinine indicated established acute renal failure[27].

Hyperglycemia is a known cause of enhanced plasma free radicals concentration. These are many ways by which hyperglycemia may increase the generation of free radicals. The term “auto-oxidation glycosylation” described the capability of glucose to analyze, there by reducing molecular oxygen and yielding oxidizing intermediates. The pathophysiology of hyperglycemia is characterized by changes in extracellular fluid volume and in effective osmolality[28]. Many authors have reported incidence of hyponatremia was 19.69 percent in all renal failure patients, and defined as serum sodium 130 mEq / L[29]. Nitrogenous waste products from protein metabolism are retained in the body, resulting in azotemia, as evidenced by the increased serum levels of urea nitrogen[30].

Oxidative stress is defined as an imbalance between formation of reactive oxygen species and antioxidative defence mechanism. Reactive oxygen species can damage protein, carbohydrate, and nucleic acids[31]. Unlike complete reduction, incomplete reduction of molecular oxygen of free radical formation. It is estimated that 1 to 3 per cent of oxygen consume by cells are channeled into the generation of reactive oxygen species[32]. Reactive oxygen species are intermediary metabolites that are normally produced in the course of oxygen metabolism[33, 34]. The oxidative-antioxidative system imbalance leads to the pathology called oxidative stress[35]. Acute renal failure can be triggered or aggravated by reactive oxygen species but established acute renal failure per se might also affect the antioxidant defense mechanisms of the organism[36]. The role of reactive oxygen species in ischemic acute renal failure remains in question. Some studies in animals show that antioxidants or scavengers of reactive oxygen species protect against functional tissue damage whereas other studies do not[37, 38].

Among the defence system operating against the reactive oxygen species, superoxide dismutase, glutathione peroxidase, and catalase are the most important antioxidant enzymes (AOEs)[39]. The glutathione peroxidase / glutathione system may be important in low-level oxidative stress. Catalase is an intracellular antioxidant enzyme that is mainly located in cellular peroxisomes and to some extent in the cytosol, which catalyzes the reaction of hydrogen peroxide to water molecular oxygen. Catalase is very effective in high-level oxidative stress and protects cells from hydrogen peroxide produced within the cell[40]. Superoxide dismutase is generally thought to play a central role because it scavenges superoxide anion at the initial step of the radical chain reaction[41].

Malondialdehyde a secondary breakdown product of fatty acid peroxide, is a highly reactive substance, and even in physiological concentration can react with erythrocyte membrane phospholipids, cross-linking their polar heads[42]. When modified by malondialdehyde, red blood cells lose their normal cationic gradient and show reduced deformability in vitro, in addition to a significantly shortened life span in vivo.[(43)] Oxidative stress occurs when there is an excessive free radical production and low antioxidant defence and results in chemical alteration of biomolecules which cause structural and functional modifications. Polysaturated fatty acids are oxidized in vivo by free radicals and other species. Degradation of oxidized lipid molecules leads to the formation of malondialdehyde in excess.[44]

Therefore, the present study on patients of acute renal failure of different age groups in male sexes makes us conclude that if the estimation of serum sodium, potassium, protein (Total), creatinine, urea, antioxidant enzymes, and oxidant product are done in the newly diagnosed cases may be suggestive for early phase of disease. Oxidative stress in elderly patients intensified especially if the patients have associated with renal complications especially in middle age. This can fore warm the patients for prophylactic measures as would be suggested by the treating physician.

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