Sumerianz Journal of Medical and Healthcare, 2021, Vol. 4, No. 2, pp. 114-122
ISSN(e): 2663-421X, ISSN(p): 2706-8404
Website: https://www.sumerianz.com
DOI: https://doi.org/10.47752/sjmh.42.114.122

Original Article Open Access

Assessment of Electrolytes, Urea and Creatinine in Patients with Renal Impairment Attending Yobe State Specialist Hospital Damaturu

Abubakar El-Ishaq*
Department of Science Laboratory Technology School of Science and Technology The Federal Polytechnic Damaturu, Nigeria
Email: ishaq_abubakar@yahoo.com

Amina M. Garba
School of Nursing Damaturu, Nigeria

Deji Dairo Emanuel
Department of Science Laboratory Technology School of Science and Technology The Federal Polytechnic Damaturu, Nigeria

Article History
Received: April 5, 2021
Revised: June 15, 2021
Accepted: June 20, 2021
Published: June 22, 2021

Abstract

Electrolytes, urea and creatinine are major factor in the determining a healthy kidney performance. Renal impairment is one of the kidney stages that can alter the concentration of these electrolytes. This study was carried out in order to access the biochemical concentrations of urea, electrolytes and creatinine in patients with renal impairment attending Yobe state specialist hospital Damaturu. One hundred (100) blood samples were collected randomly from the patients. Automated chemistry analyzer (Selectra proS) was used for determination of urea and creatinine. For the determination of concentration of electrolytes in blood samples, electrolytes analyzer known as Ion selective electrolyte (ISE) was used. Electrolytes determined and compare with normal values includes: bicarbonate (HCO_3-) 20-30 mmol/l, potassium (K+) 2.5-5.0 mmol/l, chloride (Cl-) 95-110 mmol/l, and sodium (Na+) 135-145 mmol/l. The results obtained was distributed into three (3) groups depending on the age categories; group 1 (1-30years), group 2 (31-60 years), and group 3(60-90 years). The gender ratio male to female patients examined was 52:48. Generally, the obtained result showed that females age 31-60 years are the most affected by the renal impairment, and this called for Government intervention in order to solve the causes of kidney impairment in the society.

Keywords: Blood chemistry; Concentration; Electrolytes; Glomerular; Kidney; and Renal impairment.

1. Introduction

Kidney injury (KI) has traditionally been defined as a loss of kidney function with resultant accumulation of nitrogenous waste and deregulation of electrolytes and blood volume. In most cases, renal diseases are asymptomatic. Laboratory tests are often employed to evaluate glomerular and tubular functions [1]. As Glomerular filtration rate (GFR) declines, a wide range of disorders develops, including fluid and electrolytes imbalance such as hyperkalemia, metabolic acidosis, volume over load and hypophosphatemia. As glomerular function deteriorates, substances that are normally cleared by the kidneys accumulate in the plasma. The biochemical investigations of renal function can be used to diagnose the presence of renal dysfunction or the severity of the disorder and response to treatment. Kidney dysfunction (KD) is known to be an independent predictor of poor in-hospital outcome [2]. Biochemical markers play an important role in accurate diagnosis and also for assessing risk and adopting therapy that improves clinical outcome. Over the decades, research and utilization of biomarkers has evolved substantially. Markers of renal function such as creatinine, urea and electrolytes are for routine analysis. Patients that undergo major orthopedic procedures can also be at high risk for kidney disease due to severe electrolytes disturbances, development of preoperative infection, and presence of several comorbidities that may impair renal function in addition, pre- or post-operative KD is one of the risk factors for postoperative complications, including acute renal failure and cardiovascular disease, leading to increased mortality and morbidity [2].

Hemodialysis is one of the renal replacement therapy. The technique plays a vital role in the process for the extracorporeal removal of waste products such as creatinine, urea and free water from the blood, when the kidneys are impaired. The principle behind hemodialysis is the diffusion of solutes through a semi permeable membrane [3]. Hemodialysis is usually performed with uremic patients for two to three times a week and the required times for dialysis vary from two to four hours. The difference in the time of dialysis depends on various factors, including kidney function, amount of waste in body, level of salts and body weight. Dialysis improves many symptoms of kidney failure, but some problems including hypertension, anemia and desire often require additional drug treatments as well [3].

The estimated number of CKD cases in Nigeria is between 50,000 [4] and 60,000 annually with only 27 dialysis units for an estimated population of 180,000,000, and fewer than 50 hemodialysis are done locally [4]. Currently in Nigeria, about 36.8 million people are CKD patients who need either the expensive dialysis or kidney transplant

*Corresponding Author

process. Hence, the need to assess the electrolytes urea and creatinine on such patients, the most commonly requested biochemistry tests. Also Endocrine activity which means regulating blood pressure, supporting red blood cell production and contributing to blood calcium. Excretion which involves removal of urea and creatinine, kidneys consist of millions of single-functional units called nephrons. The top of a nephron is known as the glomerulus; this is an important filter that interfaces directly with the blood and has a major role in regulating the composition of blood and urine [5].

Kidney disease, also known as nephropathy, is damage to kidney. Nephritis is an inflammatory kidney disease and has several types according to the location of the inflammation. Inflammation can be diagnosed by blood tests. Nephrosis is non-inflammatory kidney disease. Nephritis and nephrosis can give rise to nephritic syndrome and nephrotic syndrome respectively [6]. Kidney disease usually causes a loss of kidney function to some degree and can result in kidney failure, the complete loss of kidney function. Kidney failure is known as the end-stage of kidney disease, where dialysis or transplant is the only treatment option. Chronic kidney disease causes the gradual loss of kidney function over time. Acute kidney disease is now termed acute kidney injury and is marked by the sudden reduction in kidney function over seven days [6].

Chronic kidney disease (CKD) is defined as structural or functional abnormalities of the kidney that persist for at least 3 months and is manifested by either kidney damage (most frequently expose as persistent albuminuria or proteinuria (> 30 mg/24 h or > 1 on specific dipstick); or a decreased glomerular filtration rate (GFR), (< 60 ml/min per 1.73 m^2). Early CKD has no symptom; this is why CKD usually remains undetected for a longer period, until a screening test identifies the silent problem. CKD in many patients remains unidentified because of screening for albuminuria is not regularly performed. GFR specifically estimates how much blood passes through the glomerular [7]. It is accepted as the best index of overall kidney function. Chronic Kidney diseases can also be defined as the presence of kidney damage, manifested by abnormal albumin excretion, decreased kidney function, quantified by measured glomerular filtration rate (GFR) that persists for more than three months [8] . The disease includes conditions that damage the kidneys and decrease their ability to keep them healthy. It may result to complications like high blood pressure, anemia, weak bones, poor nutritional health and nerve damage. Also, kidney disease increases the risk of having fluid overload, heart and blood vessel disease. These problems may happen slowly over a long period of time [7].

Sodium is the main extracellular cation. The plasma sodium level is a major factor in the control of water homeostasis and extracellular fluid volume. An increase in plasma sodium normally results in three compensatory mechanisms coming into play, thirst prompts oral fluid intake, anti-diuretic hormone (ADH) secretion from the pituitary is increased, leading to renal water retention; there is a shift of water from intracellular to extracellular space. As the total intake of sodium chloride is almost completely absorbed from the gastrointestinal tract with no active control, regulation of the retained body sodium is maintained by the kidneys, with the excess excreted in the urine and fine control carried out by tubular reabsorption. After initial glomerular filtration some 60% of the filtered sodium is recovered in the proximal tubules together with bicarbonate. 25% is reabsorbed in the Loop of Henle of the renal tubule with chloride; the remainder is reabsorbed in the distal tubules where, with aldosterone governing its reabsorption, it competes with potassium and hydrogen ions [8]. Sodium is primarily responsible for maintaining osmotic pressure. Increased serum sodium is present in states of dehydration as a result of diarrhea or vomiting. Low sodium levels usually are as a result of too much water in the body. High levels of sodium can raise blood pressure and may indicate dehydration [9].

Potassium is the principal intracellular cation, 98% of which is maintained within the cells by the ATP dependent mechanism known as the sodium pump. Any sodium which diffuses into cells is actively excreted in exchange for potassium, insulin also accelerates the cellular uptake of potassium and elevated levels of plasma, potassium encourage secretion of insulin. In addition to its role in intracellular osmolality, potassium is essential for many enzymatic reactions, the regulation of heart muscle, and for the transmission of nerve impulses. An important factor in the control of potassium cellular transport is the acid/base status [10]. In acidosis the flow of hydrogen ions into cells causes the outflow of an equivalent number of potassium ions. Dietary potassium intake is normally in excess of requirement and the surplus is excreted via the kidneys. Following potassium ingestion, aldosterone secretion is increased to enhance renal clearance and insulin levels rise to increase cellular absorption [10]. Serum potassium is the most convincing electrolyte marker of renal failure. The combination of decreased filtration and decreased secretion of potassium in distal tubule during renal failure cause increased plasma potassium. Hyperkalaemia is the most significant and life-threatening complication of renal failure [10]. Potassium supplementation is rarely necessary in patients with advanced CKD. Transient hypokalaemia after hemodialysis does not usually require supplementation. If recurrent, best to alter the $[K^+]$ of the dialysate. This is safer than supplementation. If potassium supplementation is required, give small amounts and re-check.

Critically ill patients receive large amount of intravenous fluid administration during their ICU stay. Many commercially available crystalloid fluids are rich in chloride, such as the most widely used saline 0.9% that has 40% higher chloride than human plasma. Some animal studies suggest that administration of chloride liberal fluid induces renal vasoconstriction and a decline in glomerular filtration rate [11]. Decreasing kidney function causes progressively increased retention of acids, resulting in numerous deleterious consequences, such as protein catabolism and protein-energy wasting, worsening uremic bone disease and an association with decreased functional capacity and with increased mortality. Metabolic acidosis has also been linked directly to kidney damage and to increased progression of CKD, possibly through mechanisms associated with adaptive responses meant to enhance acid excretion in the face of progressive loss of kidney function. The association between elevated serum bicarbonate concentrations in patients with kidney disease is positive and should be taking to consideration in every patient with the disease [12].

Sankar, *et al.* [13] reported that, low serum bicarbonate levels are associated with death among stage 3 CKD, while high serum bicarbonate levels are associated with death among both stage 3 and stage 4 CKD patients. Urea is a waste product of metabolism that is excreted by the kidneys in urine. Kidney disease is associated with reduced urea excretion and consequent rise in blood concentration. Once the primary laboratory test for detection and monitoring of reduced renal function, that role is now fulfilled by the plasma/serum creatinine test. The limitation of urea as a test of renal function relates to reduced sensitivity and specificity so that a normal urea does not necessarily exclude renal disease and a slight to moderate increase in urea cannot be assumed to be due to renal disease [14].

2. Materials and Method

The blood samples (3-5ml) of renal impaired subjects were collected and placed into plain containers (lithium heparin), centrifuged at 3,000 rp for 3 minutes before separation of serum. Samples are labeled accordingly. and stored at 4oC for 1-8 days before further analysis. Samples that could not be analyzed within this period were kept frozen. All samples for the analysis were collected and analyzed at Heamatology Laboratory Yobe state specialist hospital Damaturu. The blood samples were analyzed using Selectra proS blood chemistry analyzer, while Ion selective electrolytes analyzer was used for the determination of blood electrolytes [15]. This Electrolytes Analyzer specifically designed for the direct determination of Na^{+}, K^{+} and Cl^{-} by ion selective electrodes in whole blood, serum, and aqueous material.

2.1. Experimental Design

A total of (100) hundred subjects were used for the analysis and were analyzed for the concentration of electrolytes levels comprising of sodium, potassium chlorine and calcium, as well as urea and creatinine levels. The analysis was divided into three groups as follows: Group 1: Renal impaired patience of 1-30 years both male and female. Group 2: Renal impaired patience of 31-60 years both male and female, Group 3: Renal impaired patience of 61-90 years both male and female

2.2. Procedure

After the arrangement for using the machine had been put in place, positions were set on the sample tray and corresponding items was placed in the sample tray. The reagent bottles on the reagent tray were opened and the machine was covered. Sample testing began after which the results were displayed on the screen.

The electrolytes machine was switched on and allowed to calibrate itself automatically this could take a couple of minutes, the sample number was registered appropriately and then aspirate button was pressed on the machine. The sample was aspirated and the result print out.

3. Results

A total of hundred (100) subjects were recruited for this study. The results obtained as presented in the figures below show the age ranges, sexes, concentration of some electrolytes which includes: sodium (Na^{+}), potassium (K^{+}), chloride (Cl^{-}) and bicarbonate (HC_3O^{-}), urea and creatinine concentration (mmol/L).

Figure-1. Number of patients versus Age ranges (Sex)

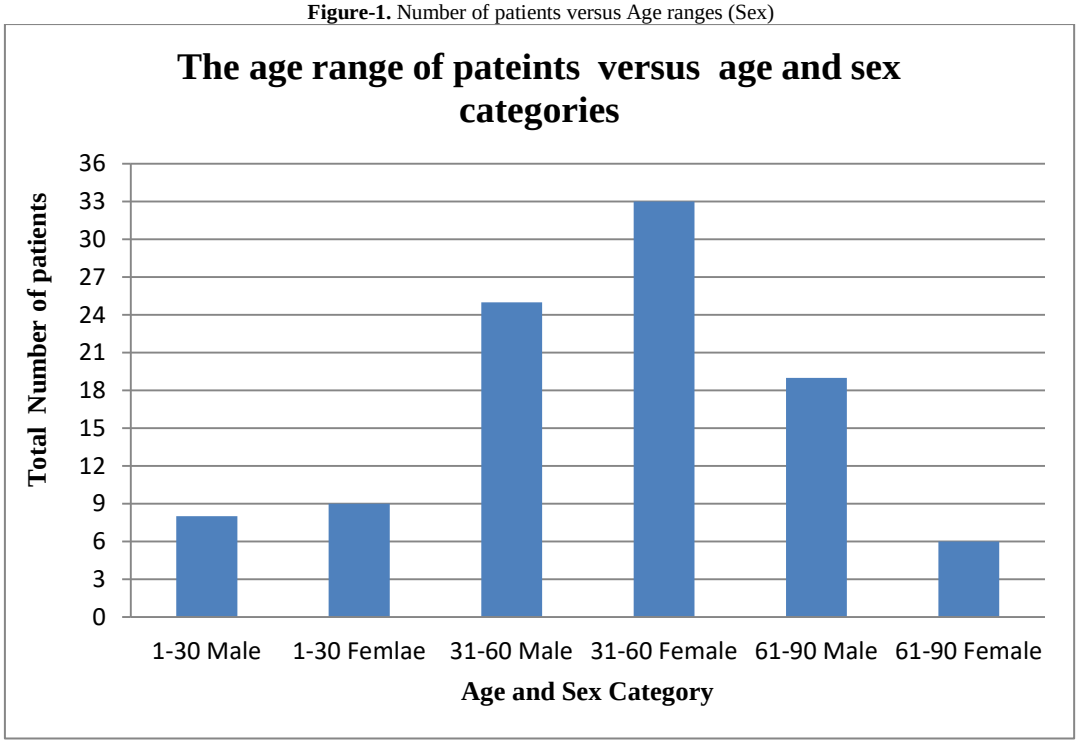


Figure-2. Number of patients versus Sex

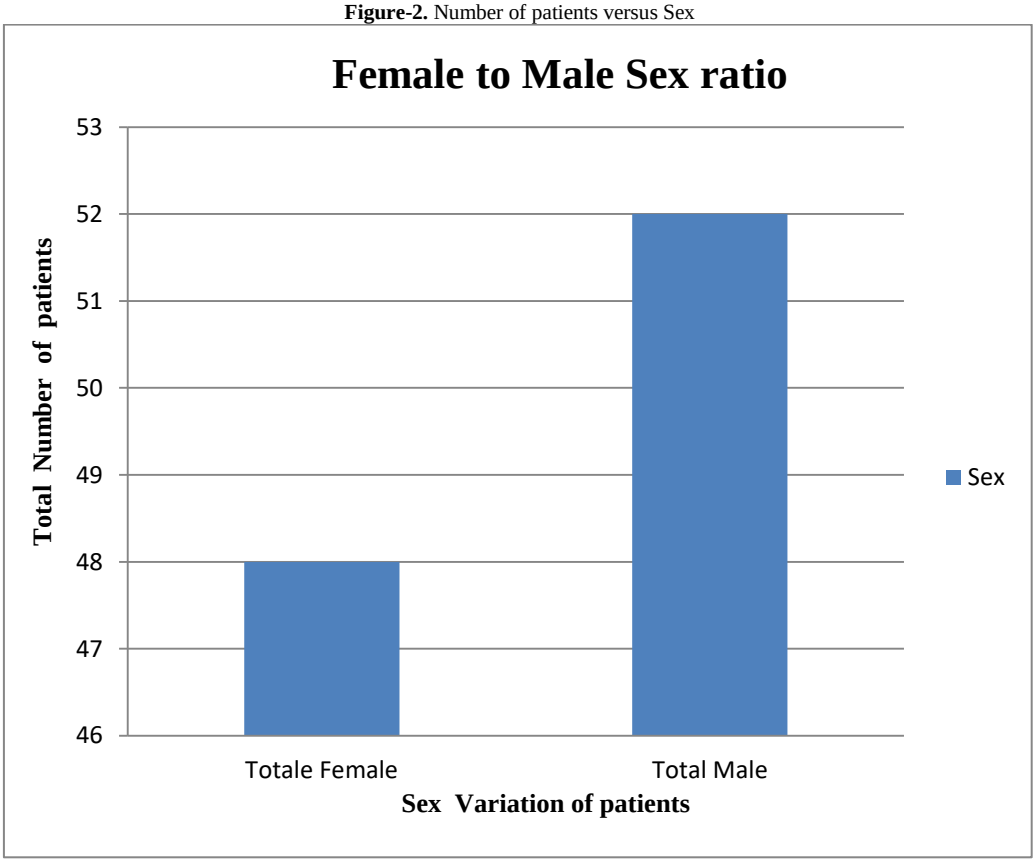
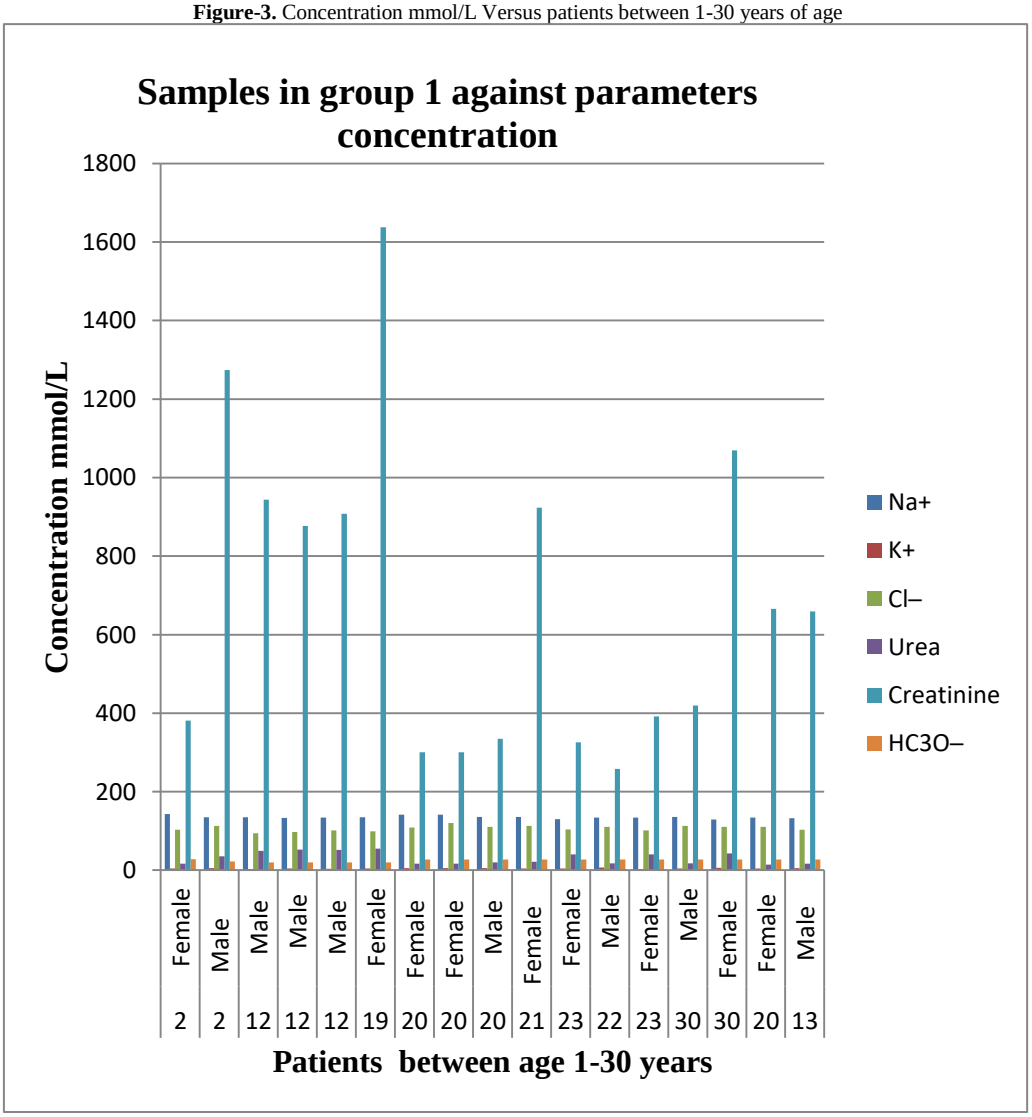


Figure-3. Concentration mmol/L Versus patients between 1-30 years of age



Figur-4. Concentration mmol/L Versus patients between 31-60 years of age

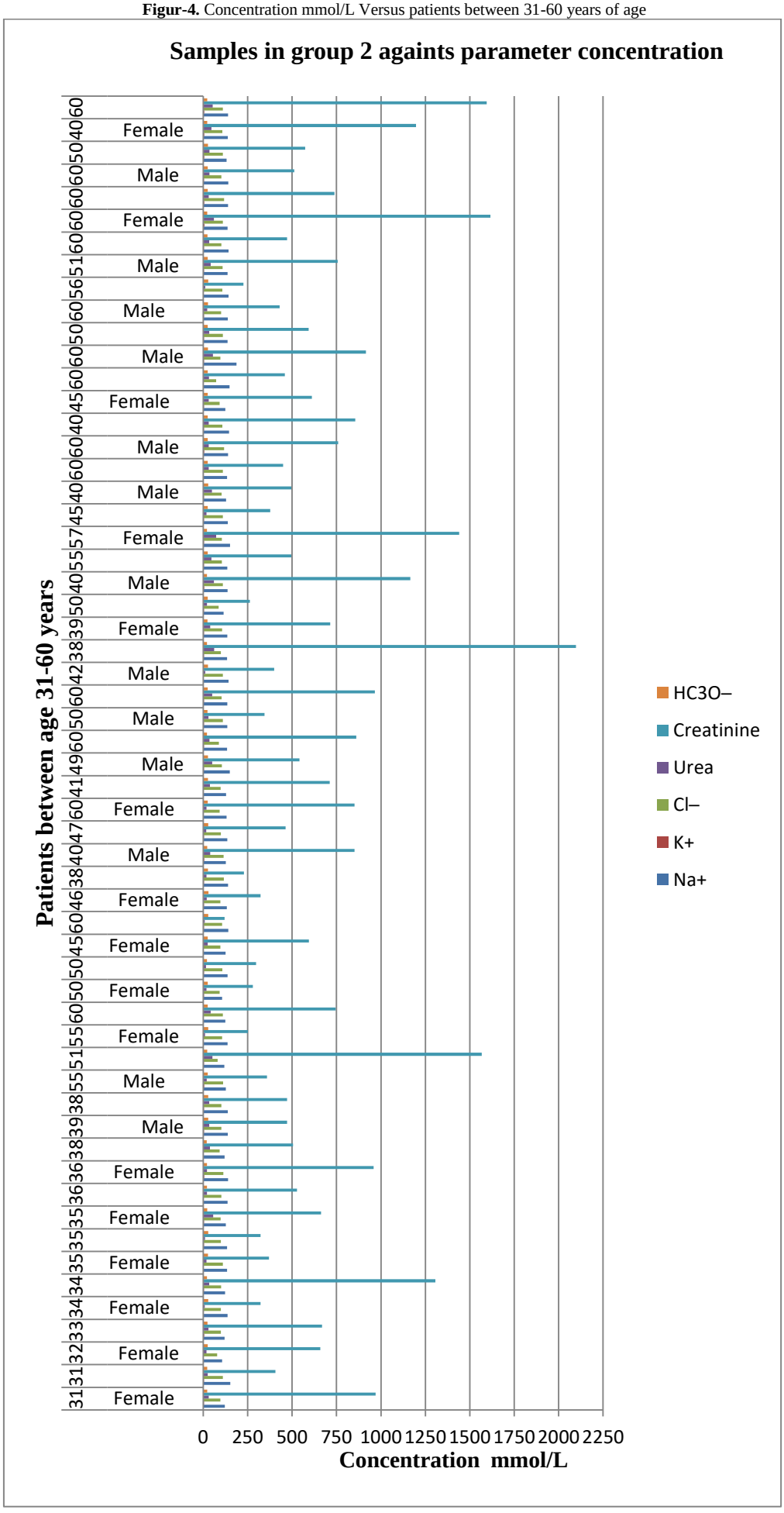
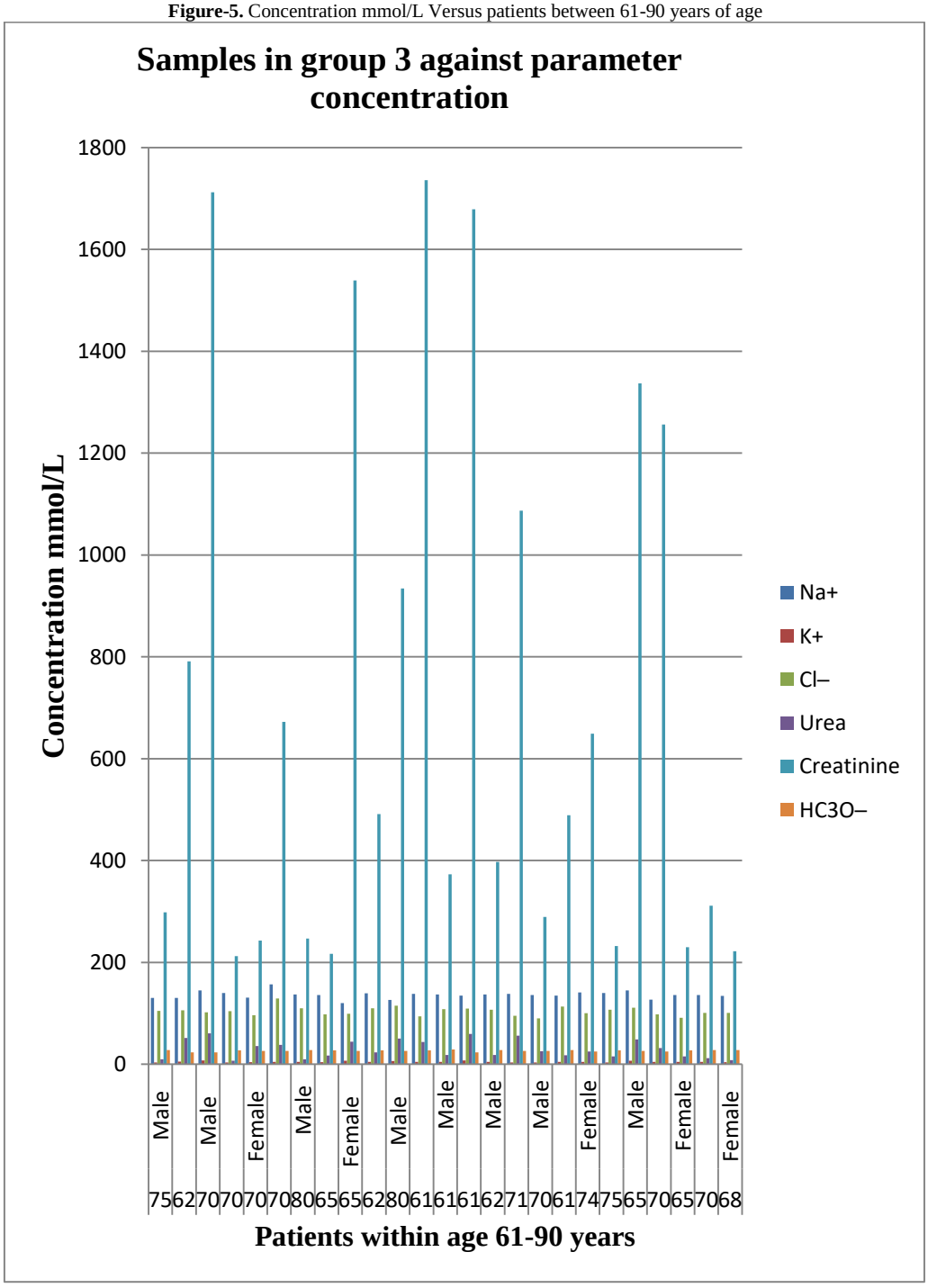


Figure-5. Concentration mmol/L Versus patients between 61-90 years of age



4. Discussion

Little literature was found on the biochemical assessment of electrolytes, urea and creatinine levels in renal impaired patients. However in this study, sufficient records of creatinine, urea and electrolytes such as sodium, potassium, bicarbonate and chloride was investigated in hundred (100) blood samples of patients diagnosed of renal impairment in Yobe state specialist hospital Damaturu. The result as illustrated in group one, seventeen (17) patient's fell under this category which comprises of eight (8) Male subjects and nine (9) female as illustrated in figure: 1, from the data it was discovered some subjects fell within the age of 2 years as well as the age of 12 years. This shows that young children as well can fall victim of renal impairment, kidney diseases can affect children in various ways, ranging from treatable disorders without long term consequences to life threatening conditions, children with renal failure can face several challenges which can include: a negative self-image, relationship problems , behavior problems, learning problems, trouble concentrating, delayed language skills development as well as delayed motor skill development, this can be associated with some of the causes such as birth defect, hereditary diseases, infection, and a medical situation known as nephrotic syndrome, systematic diseases, urine blockage or reflux this characterized [16].

A birth defect is a problem that happens when a baby is developing in the mother's womb. Some birth defects that affects kidney include renal agenesis, renal dysplasia, and ectopic kidney, to name a few. These defects are abnormalities of the size, structure, or position of kidneys: renal agenesis which describes children born with only one kidney, renal dysplasia which means children born with both kidneys, yet one does not function, ectopic kidney

which describes children born with a kidney that is located below, above, or on the opposite side of its usual position [17]

Hereditary kidney diseases are illness passed from parents to child through the genes such as the famous polycystic kidney disease (PKD), characterized by many grapelike clusters of fluid filled-cyst-abnormal sacs that make both kidneys larger over time. These cysts take over and destroy working principle of the kidney tissues. Another hereditary disease is Alport syndrome, which is caused by mutation in a gene for a type of protein called collagen that makes up the glomeruli. Alport syndrome generally develops in early childhood and it is more serious in boys than in girls [18].

The creatinine levels of patients diagnosed are of different variation as compared to the laboratory standard, the minimum range of creatinine in blood should actually fall in between 44-132 mmol/L, from the results it implies that the patients all have higher levels or concentration and did not fall within the normal limits. The kidneys maintain the blood creatinine in a normal range, creatinine has been found to be fairly reliable indicator of kidney function. Elevated creatinine level signifies impaired kidney function or kidney diseases. As the kidney become impaired for any reason, the creatinine level in the blood will rise due to poor clearance of creatinine by the kidneys. Abnormally high levels of creatinine thus warn of possible malfunction of failure of the kidneys. It is for this reason that standard blood test routinely check the amount of creatinine in the blood [18].

As compared with the clinical laboratory standard, the required urea level which is between the range of (2.5-5.5 mmol/L) from the results and data obtained its illustrate that all obtained values are higher than the required range, this implies that patients are kidney impaired. Blood urea level is another indicator of kidney function. Urea is also a metabolic by product which can build up if kidney function is impaired. The blood urea ratio can actually give a more information about kidney function and its possible underlying cause compared with creatinine level alone blood urea also increases with dehydration [14].

Urea is the major metabolic product of protein catabolism. The biosynthesis of urea from ammonia is exclusively carried out by hepatic enzymes more than 90% of urea is excreted through the gastrointestinal tract or skin. Blood urea concentrations can be increased by numerous factors linked to prerenal causes or renal/postrenal causes. Uremia is also increased by high-protein diet, state of dehydration, muscle wasting. The determination of urea rate is used together with the determination of creatinine rate to discriminate between prerenal postrenal disorders. Urine urea may be used as an indicator of overall nitrogen balance and as a guide to total amino acid requirements for patients with parenteral nutrition [19].

The results of patients with renal impairment between the age categories of 31-60 years, acute kidney failure is as well prompt in adults, it was as well noticed that adults from the age range of 31-60 years fall more victim of renal impairment having about fifty-eight (58) patients under this category. It was also noticed that female folks fall more victims of the circumstances as compared with male counterpart having a total of thirty-three (33) female and a total of twenty-five (25) male.

Diabetes and high blood pressure are the most common causes of chronic kidney disease, too much glucose, in the blood damages the kidney's filters. Over time the kidney can be so much damaged that they no longer do a good job filtering waste and extra fluids from the blood. This can be related to patients with higher concentration of creatinine of above (1200mmol/L), these patients are liable to die soon except them under hemodialysis as often as possible to reduce the level of bold waste from the body [18]. Hemodialysis is a process of purifying the blood of a person whose kidneys are not functioning properly, this dialysis achieves the extracorporeal removal of waste products such as creatinine and urea from the blood when the kidney are in a state of kidney failure. Hemodialysis is one of the three renal replacement therapies, the other two being kidney transplant and peritoneal dialysis, an alternative method for extracorporeal separation of blood components such as plasma or cells is apheresis [20].

High blood pressure can damage blood vessels in the kidneys so they don't work as well, if the blood vessels in the kidneys are damaged the kidney may not work as well to remove waste and extra fluids from the body, extra fluids in the blood vessels may raise blood pressure even more, creating dangerous cycle [21]. Adults who are found of taking excess drugs such as alcohol, heavy drinking can hurt the kidneys including the livers, cocaine, heroin and amphetamines also contributes to destruction of the kidney. Numerous drugs can affect the function of the kidney, nicotine contained in tobacco products is a toxic substance, use of nicotine increases blood pressure, and the increase can accelerate damages to the kidneys. Chronic heavy alcohol consumption can also lead to kidney swelling, which can impair renal functioning, it also alter the acidity levels of the fluids in the system, which can result in alcoholic ketoacidosis, a condition that is characterized by a significantly dangerous high blood acidity level, and produce alkalosis [22]

Nicotine also exacerbates kidney diseases and increases the risk of kidney failure in individuals who have certain medical conditions such as type I diabetes. Smoking is associated with many complication that can affect kidney functioning, however the high rate of smokers in Yobe state contributes to the high risk of renal impairment especially in male subjects, smoking have a major effect on the kidney which includes: increased in levels of albumin in urine that can be associated with cardiovascular disease, narrowing of the renal arteries, including disruption of the balance of fluid and electrolytes in the system [23].

Adult males may be at higher risk of kidney diseases due to the type of jobs they acquire, industrial works where by individuals are exposed to hazardous chemicals either by inhalation can as well contributes to this diseases, toxic gases inhaled from refineries, even spray paints, cleaning fluids and glues, a toxic chemicals known as toluene which is a component of many substances used as solvents which are abused as inhalants, can lead to direct kidney damage when ingested. The damage will often occur as the result of lesions to the kidney which may as well produce some serious condition known as renal tubular acidosis in which acids builds up in the blood and can lead to chronic kidney failure [24].

Total number of female within the second group (31-60years) was thirty-tree (33), women tend to face more specific challenges linked to kidney disease. The risk of developing chronic kidney disease (CKD) is at least high in women as in men. It is observed that the total number of females with renal impairment is fourty-eight (48), while male subjects have a total of fifty-two (52), giving a difference of four (4). The type of kidney disease associated in female patients includes: lupus Nephritis, kidney damage caused by autoimmune disease, a disorder in which the body's immune system attacks the body own cells and tissues, pyelonephritis a type of urinary tract infection (UTI) that is most commonly caused by bacteria and starts in the lower urinary tract, if not treated it moves upstream to one of both kidneys. This can lead to sepsis which can be life threatening [25].

Kidney diseases can develop at any time, but those over the age of 60 are more likely than not to develop kidney disease, as people age so do their kidneys too. The national kidney foundation (NKF) urges everyone over the age of sixty (60) to be screened for kidney diseases. From the third category results recorded it is observed that the total number of male patients in this category is nineteen (19) while total number of females is six (6), this signifies that, male subjects are prompt to renal diseases than female subjects at age sixty (60) above. The most common cause of kidney failure in the elderly includes high blood pressure when left untreated; this can increase the risk of heart attack, stroke and loss of vision [16].

5. Conclusion

This study indicates the level of creatinine, bicarbonate, urea and electrolytes in patients with renal impairment attending Yobe state specialist hospital Damaturu. It was concluded that all the 100 samples collected shows high levels of creatinine and urea concentrations in mmol/L which are above the standard measuring limits in the hospital laboratory, thus implies that all patients are renal impaired, it was concluded that individuals have different concentration of electrolytes, urea and creatinine concentration depending on age and sex. Prevention is always the goal with kidney failure. Chronic diseases such as hypertension (high blood pressure) and diabetes are devastating because of the damage they can do to the kidneys and other organs. It is important in keeping blood sugars and blood pressure under normal limits. Specific treatment depends on the underlying diseases.

Once kidney failure is present, the goal is to prevent further deterioration of renal function. If ignored, the kidneys will progress to complete failure but if underlying illness are addressed and treated aggressively, kidney function can be preserved, though not always improved.

Different classes of medication may be used to help control some of the issues associated with kidney failure including: phosphorus-lowering medications such as calcium carbonate (citrate), calcitriol, iron supplement as well can help control renal failure including vitamins and blood pressure medications. Once the kidneys fail completely, the treatment options are limited to dialysis or kidney replacement by transplantation.

References

[1] Sehgal, V., Sukhminder, S. B., Rinku, S., Jeremiah, E., Praveen, R., and Samuel, M., 2014. "Predictors of acute kidney injury in geriatric patients undergoing total kidney replacement surgery." *Int. J. Endocrinol Metab*, vol. 12, p. e6713.

[2] Adamu, S. M., Wudil, A. M., Alhassan, A. J., Koki, Y. A., and Adamu, S., 2016. "A review on biomarkers of kidney dysfunction in orthopedic cases." *Journal of Dental and Medical Sciences (IOSR-JDMS)*, vol. 15, pp. 88-98.

[3] Nisha, R., Srinivasa, S. R., and Thanga, M. K., 2017. "Biochemical evaluation of creatinine and urea in patients with renal failure undergoing hemodialysis." *J. Clin. Path. Lab. Med.*, vol. 1, pp. 1-5.

[4] Blann, A., 2014b. "Nurs times." vol. 110, pp. 19-2. Available: https://www.ncbi.nlm.nih.gov/pubmed/24600964

[5] Blann, A., 2014a. "Routine blood tests 1: why do we test for urea and electrolytes?" *Nursing Times*, vol. 110, pp. 19-21.

[6] Coresh, J. S., Elizabeth, S., Lesley, A., Manzi, J. K., John, W. E., Paul, V. L., Frederick, L., and Andrew, S., 2007. "Prevalence of chronic kidney disease in the United States." *J. A. M. A.*, vol. 298, pp. 2038–2047.

[7] Nigwekar, S. U., Tamez, H., and Thadhani, R. I., 2014. "Vitamin D and chronic kidney disease–mineral bone disease (CKD–MBD)." *Bonekey Reports Official Journal of the International Bone and Mineral Society*, vol. 3, p. 498.

[8] Robert, T., Abbas, K., and John, R. S., 2008. "Chronic kidney disease and it's complications." *Prim. Care.*, vol. 35, p. 329.

[9] Yousafzai, A., Ara, S., Javed, F., Jahan, N., Ahmed, N., Waseem, M., and Asif, M., 2011. "Kidney function tests and serum electrolyte disorders in different ethnic groups of Balochistan." *Journal of Applied And Emerging Sciences*, vol. 2, pp. 164-170.

[10] Gowda, S., Desai, P. B., Kulkarni, S. S., Hull, V. V., Math, A. K., and Verneker, S. N., 2010. "Markers of renal function tests." *J. Med. Sci.*, vol. 2, pp. 170-173.

[11] Zhang, Xu, X., Fan, H., Li, D., and Deng, H., 2013. "Higher serum chloride concentrations are associated with acute kidney injury in unselected critically ill patients." *BMC Nephrology*, vol. 14, p. 235.

[12] Khitan, Z. J., 2015. "Elevated serum bicarbonate concentration in chronic kidney disease: A call to find the cause." *Journal of American Heart Association*, vol. 4, p. 001997.

[13] Sankar, D., Navaneethan, S. D., Schold, J. D., Arrigain, S., Jolly, S. E., Wehbe, E., Raina, R., Simon, J. F., Srinivas, T. R., *et al.*, 2011. "Serum bicarbonate and mortality in Stage 3 and Stage 4 chronic kidney disease." *Clin. J. Am. Soc. Nephrol.*, vol. 6, pp. 2395-2402.

[14] Chris, H., 2016. "Urea and the clinical value of measuring blood urea concentration. Little Acre, Main Road Sherrington Nr Cheltenham Gloucester GL51 4XF, UK." Available: www.acutecaretesting.org

[15] Medica, 2020. "Ion-Selective Electrode (ISE). Clinical chemistry analyzers. Medical corporation. All rights reserved. Medica corporation. 5 Oak park drive. Bedford, ma 01730, USA. ." Available: www.medicacorp.com

[16] National Kidney Foundation Inc New York, 2015. "About chronic kidney disease." In *National Kidney Foundation Inc New York.*

[17] Nwose, E. U., Igumbor, E. O., Agofure, O., Bwititi, P. T., Oshionwu, E. J., Odufu, A., and Okuzo, J. N., 2020. "Development of diabetes register in low-mid income country VII: summary of series." *Int. J. Community Med. Public Health*, vol. 7, pp. 306-10.

[18] Odewusi, O. O. and Oyedeji, S. O., 2015. "Study on the stage of presentation of acute kidney injuries to clinics in western nigeria the official journal of the society for cellular pathology scientists of Nigeria." *African Journal of Cellular Pathology*, vol. 4, pp. 29-33.

[19] Griffin, R. P., 2010. *National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK)*. NIH. U. S. : Department of Health and Human Services.

[20] Chris, H., 2004. "An Introduction to acid-base balance in health and disease." pp. 1-8. Available: https://acutecaretesting.org/en/articles/an-introduction-to-acidbase-balance-in-health-and-disease

[21] Zhang, Qie, Y., and Zhang, Q. H., 2015. "Incidence and mortality prognosis of dysnatremias in neurologic critically ill patients." *Eur. Neurol.*, vol. 73, pp. 29-36.

[22] Kidney Disease: Improving Global Outcomes (KDIGO) CKD-MBD Work Group, 2009. "KDIGO clinical practice guideline for the diagnosis, evaluation, prevention, and treatment of chronic kidney disease-mineral and bone disorder (CKD-MBD)." *Kidney. Int. Suppl.*, vol. 113, pp. S1-S130.

[23] Chertow, G. M., Levy, E. M., Hammermeister, K. E., Grover, F., and J., D., 2016. "Independent association between acute renal failure and mortality following cardiac surgery." *J. A. M. A.*, vol. 104, pp. 343-348.

[24] Burtis, C. A., Ashwood, E. R., and Bruns, D. E., 2008. *Tietz fundamentals of clinical chemistry*. 6th ed. USA: Saunders Elsevier. pp. 631-717.

[25] Block, G. A., Hulbert-Shearon, T. E., Levin, N. W., and Port, F. K., 2013. "Association of serum phosphorus and calcium and phosphate product with mortality risk in chronic hemodialysis patients: A national study." *American Journal of Kidney Disease*, vol. 31, pp. 607-617.