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Determinant of Renal Function: Using Serum Renal Biochemistry Data

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ABSTRACT: *kidney is one of the most vital organs found in the body; being the body's natural filtration system, its adequacy in carrying out the function is determined by the concentration of some chemical substances contained there in the blood: Sodium ion (Na^+), Potassium ion (K^+), Chloride ion (Cl^-), Hydrogen bicarbonate (HCO_3), Urea and Creatinine. This study examined the effects of these substances on the kidney's adequacy in both combined and individual state. A secondary of serum renal biochemistry data obtained from department of Clinical Pathology, University of Maiduguri Teaching Hospital (UMTH) was used. A statistical tool of Analysis of Variance was used accomplished the objectives of the study, a post-hoc was also carried out to identify those substances that affect the renal system the most. The results obtained shows that virtually all the substances has significant effect on the kidney's adequacy in both combined and individual states with sodium (Na^+) on the lead.*

KEYWORDS: *Creatinine, Hydrogen -bicarbonate , Renal/kidney, serum, Urea.*

I. INTRODUCTION

The ability or rather viability of the renal system to effectively perform it function optimally as the body's filtration system: removing metabolic waste product from the blood stream, regulating the body water balance and maintaining the pH acidity/alkalinity of the body, fluid. Approximately one and a half quarters of the blood per minutes are circulating through the kidneys where waste in the form of urine. Is many a times is hindered by some conditions; which can result to rapid decline in the overall function of the renal system [1]. Renal failure results when the kidney is unable to remove or perform their metabolic function. The substances usually eliminated in the urine accumulate in the body fluids as a result of impaired renal excretion and this leads to a disruption in the endocrine and metabolic function as well as fluid, electrolytes, and acid-base disturbance [2].

[3], A small randomly collected urine sample is examined physically for things like: colour, odour, appearance and concentration; chemically for substances such as protein, glucose and pH and microscopically for the presence of cellular elements (red blood cells, white blood cells, and epithelial). If the results indicate a possibility of disease or impaired kidney function, one or more of the following additional test are usually performed to more specifically diagnose the cause and the level of decline in the kidney. These are;

Creatinine Clearance Test: This is carried out to evaluate how efficiently the kidney clears a substance called the creatinine from the blood. Creatinine is waste product of muscle's every metabolism, produced at a constant rate that is proportional to the muscle mass of the individual. Because the body does not recycle it, all the creatanine filtered by the kidney in a given amount of time is excreted through the urine, making the creatinine clearance a very specific measurement of kidney function.
Urea: is a waste product that is created by protein metabolism and excreted in the urine. The urea clearance test requires blood sample to measure the amount of urea in the blood stream and two urine specimens collected one hour apart to determine the amount of urea that is filtered, or cleared by the kidney into the urine. High blood urea Nitrogen levels can indicate kidney of dysfunction but because blood urea nitrogen is also affected by protein and liver function the test is usually done in conjunction with a blood creatinine a specific indicator of kidney function.

A carefully measurement of blood level of other elements regulated in parts by the kidney can also be useful in assessing the renal function. These include sodium, potassium, chloride, bicarbonate,, calcium, magnesium e.t.c

Electrolytes are positively and negatively charged molecules called ions; that are formed within the body's cell and extra cellular fluids, including blood plasma. The rest for ions is measured to assess kidney. Endocrine and acid bade function and are component of both kidney function and comprehensive metabolic

biochemistry profiles. These are measured together because they are both affected by bone and parathyroid diseases, and other move in opposing directions. Magnesium is another electrolyte that is routinely measured like calcium. It will cause tertiary (uncontrolled muscle contraction) when levels are too low in the extra cellular fluids. [4]

The test is needed for both diagnosis and management of kidney, and endocrine acid-base water balance and many other conditions. Their importance lies in part with the serious consequences that follow from the relatively small changes that disease or abnormal conditions may cause, for example, the reference range for potassium is 3.6 – 5.0 mmol/L. because value below 30 mmol/l are associated with arrhythmia (irregular heartbeat),, tachycardia. (Rapid hear heat) and cardiac and values above 6.0 mmol/L are associated with bradycardia (slow heartbeat) and heart failure.

Abnormal potassium cannot be treated without reference to bicarbonate, which is a measure of the buffering capacity of the plasma. Sodium bicarbonate which dissolves carbon dioxide: act together to resist changes in blood PH. For example, an increased in plasma bicarbonate indicates a condition called metabolic alkaloids, which results in blood pH that is too high. This may case hydrogen ions to shift from the cells into the extra cellular fluid is exchange for potassium.

As potassium moves into cells, he plasma concentration falls, the low plasma potassium, called hyposkalemia, should be treated by administration of potassium, but identifying and eliminating the causes of alkalosis.

Administration of potassium would result in hyperkalenia when the acid base distribute is corrected. Sodium measurement is very useful in differentiating the cause of abnormal potassium result. Conditions such as the over use of drugs that promote lower blood pressure often result in low levels of both sodium and potassium. On the other hand, cushions disease (adrenacotical over activity) and Addison's disease (adrenacoticol under activity) drive sodium and potassium in opposing directions. Chloride levels will follow sodium levels except in the case of acid-base imbalances, in which levels will follow sodium levels accept in the case of acid base imbalances a bicarbonate. In short diagnosis and management of patient within an electrolyte; disturbance is best served by measuring all four electrolytes.

Sodium is the principal extra cellular cat ion and potassium the principal intracellular cat ion. A cat ion is an ion with the positive charge. An Anion is an ion with the negative charge. Sodium levels are directly related to the osmotic pressure of the plasma. In fact, since an anion is always associated with sodium (usually chloride or bicarbonate) the plasma osmotic can be estimated. Since water will be often follow sodium by diffusion los sodium leads to dehydration and retention of sodium leads to Oedema a condition that promote increased sodium called hyperthermia, do so without promoting an equivalent gain in water such conditions include diabetes insipidus (loss of water by the kidney). Cushing's disease and hyperaalyosptrnidnism (increased sodium re-absorption). Many other conditions, such as congestive heart function failure, cirrhosis of the liver and kidney disease result in retention of sodium, but an equivalent amount of water is retained as well. This result in a condition called total body sodium excess, which causes hypertension and oedema, but not an elevated serum sodium concentration. Low serum sodium, called hyponatremia, may result from Addison's disease, executive diuretic therapy, the syndrome of inappropriate secretion of antideuretic hormone (SIADH), buns diarrhea, vomiting and cystic fibrosis, the diagnosis of cystic fibrosis is made demonstrating an elevator chloride concentration (greater than 60 mmol/L in sweat.

Potassium in the electrolyte used as hallmark sign of kidney, filtered by the kidney. However the distal tubule is sodium is reabsorbed and potassium is secreted. In kidney failure, the combination of decreased filtration and decrease secretion combine causes increase plasma potassium Hyperkalemia is the most significant and life threatening complication of kidney is also commonly caused by hemolytic anemia (release from heamolyseds red blood cells, diabetes inspidus, Addisom's diseases and digitalis include alkalosis, diarrhea, and committing, excessive use of thuzide diuretics cushing's disease, intravenous fluid administration and secretion of anti-diuretic and measured and secretion of anti-diuretic hormone (SIADH).

Calcium and phosphorus are measured together because they are both likely to be abnormal in bone and parathyroid disease states. Parathyroid hormone causes reabsorption of these minerals absorption and renal reabsorption of calcium will be increased and phosphorus will be decreased. In hyperthyroddism, serum calcium will be increased and phosphorus will be decrease. In hyperthyroidism and renal disease, serum calcium will be God but phosphorus will be high. In vitamin D dependent rickets (VDDR), both calcium and phosphorus he

low; however calcium is normal while phosphorus is low in vitamin resistance rickets (VDRR). Differential diagnosis of abnormal serum calcium is aided by the measurement of ionized calcium (i.e. calcium not bound by protein).

Approximately 45% of the below is bound to protein. 45% is ionized and 10% is completed to anions in the form of undissociated salts. Only the ionized calcium that is physiologically active level of ionized calcium is regulated parathyroid hormone (PTH), via negative feedback.

Electrolytes are measured by a process known as potentiometry. This method measures the voltage that develops between the inner and outer surfaces of an ion selective electrode. The electrode (membrane) is made of a material that is selectively permeable to ion being measured. The potential is measured by comparing it with the potential of a reference electrode, since the potential of the reference electrode s held constant; the difference in voltage between the two electrodes is attributed to the concentration of ion in the sample.
Preparation: Usually no special preparation is necessary by the patient; samples for calcium and phosphorus and for magnesium should be collected following an eight hour fact.

Precautions: electrolyte test are performed on whole blood, plasma, or serum, usually collected from vein or capillary. Special procedure called Phil phone or pilocarpine ionphore sis uses electric. Current applied to the patient in order to convey the pilocarpine to the sweat glands where it will stimulate sweating. Care must be taken to insure that the collected device does not become contaminated and that the patients' parent or guardian understands the need for the electrical equipment employed.
After care: Discomfort or bruising may occur at the picture site, or the person may feel Dizzy or faint. Pressure to the puncture site until the bleeding stops reduces bruises applying warm packs to the puncture sites relieves discomfort.

Risk: minor temporary discomfort may occur with any blood test but there are no complications specific to electrolyte test.
Normal results: electrolytes concentrative are similar whether measured in serum or plasma. Values are expressed as mill-mole per litre (mmol/litre) for sodium, potassium, chloride and bicarbonate. Since severe electrolyte disturbance can be associated with life threatening consequences such as heart failure shock coma or tetaney, alert values are used to warn physicians of the impending crisis.

Typical reference ranges and alert values are cited below.
Serum or plasma sodium: 135 – 145 mmol/L: alert levels less than 120mol/L and greater than 160mmol/L.
1. Serum of plasma potassium: 3 6 – 5.4 Mol/L; alert levels: less than 3.0 mmol/L and greater than 6.0 mmol/L
2. Serum or plasma chloride: 98 – 180 mmol/L.
3. Serum or plasma bicarbonate: 18 – 24mmol/L alert levels less mmol/L greater than 40mmol/L
4. Creatinine 80 – 125 milliliter normal clearance levels than mmol/L and greater than 40mmol/L.
5. Urea 64 -99 milililitre normal clearance levels.

Homeostasis: This is the process by which an organism regulates its internal environment and keeps it in a steady state by adjusting to any changes in the physical and chemical conditions of its body fluid these conditions include temperature, Ph. Osmotic pressure concentration of dissolved substances in the body fluid such as carbon dioxide, oxygen, urea food substance (glucose amino acid etc) and ions (sodium potassium chloride etc).

Therefore Homeostatic processes: is the control mechanism that used often to direct and adjust changes in the internal environment of an organism.

Several organs are involved in the homeostatic process which kidney plays the most vital role; others are liver, skin and hormone although; these organs and hormones plays an important role in the homeostatic process of the body.

The kidney: The paired kidneys are the excretory organs of human. They remove unwanted nitrogenous substance like Urea, and other ammonium compound from the blood.
They also maintain the osmotic pressure of the body by controlling the excretion of salts; and water.

The kidney is supplied with blood vessels. The renal artery enters the kidney. It arises directly from the dorsal aorta and brings oxygenated blood containing excretion products, the renal veins drains filters vena cava. A narrow tube the ureter connects the kidney to urinary bladder. Urine is stored in urinary bladder; the urinary bladder leads to the urethra which opens to the exterior [1]

The kidney has two distinct regions, the outer carter and the inner medulla. More than a million on fine narrow tubules

Large amount of white blood cells and dead tissue cell collects in the i9nflamed glomeruli sometimes totally blocking the blood flow. The tabular too becomes impaired as the tubules do not receive sufficient nourishment from reduced blood supply.

1. **Kidney Stones:** these are stony masses of minerals and organic matter that form in kidneys. They are produced when mineral salts in the urine come out of solution as solid crystals. This may occur. When the water intake is low, the intake of salts is higher or urine is abnormally acid or alkaline.

Kidney stone varies in size from tiny said like grains to large masses which can completely full the renal pelvis. Large stone may blocks, the flow of urine and cause infection to begin. The pressure that builds up causes severe may be dissolved by medicine. Large stones may have to be removed surgically.

2. **Diuresis:** In such condition, large quantitative dilute urine is produced. This happens if a person drinks a large quantity of water. Within an hour a large volume of very dilute urine is produced and excreted. This is known as water dieresis.

Dieresis also occur in diabetes insipidus where the production of anti-diuretic hormone stops or is greatly reduced. This results to production of daily Urine of 5-20 litres; which could only be counteracted by drinking plenty of water.

Similarly, in diabetes mellitus patient: where the excretion of glucose into the urine is accomplished by the release of large quantity of water.

3. **Oedema:** This condition is also known as dropsy. Oedema is caused by the adulation of large amount of intercellular fluid is tissues, causing the affected part to increase in volume well marked, outward signs of oedema are a puffy face and swollen ankles.

Dialysis and kidney transplant: A dialysis machine or artificial kidney consists of a long cellophane tube immerse in a water bath. The water in bath contains all the useful ions and small molecules like glucose in the same concentration as in normal plasma. The bath is maintained at body temperature.

To dialysis a blood of patient, the blood for in the artery in the arm is allowed to flow through the tube. The cellophane is semi-permeable and allows body waste to diffuse out the blood into the water bath, while retaining the plasma proteins and blood cells. Only the excess amount of ions and glucose diffuse into the bath from the blood the cleaned blood is returned to the body via the arm. This procedure takes place for about six hours.

A person with complete kidney has to cleanse his blood this way twice a week. Dialysis is usually done in a hospital. It is possible to have a small dialysis machine at home and operate it by ourselves.

With dialyses and controlled diet, a person with kidney failure can lead a fairly normal life. However, dialysis facilities are limited and expensive in many countries.

Kidney transplant: It is now possible to replace a diseased kidney with a healthy one. This operation is called transparent. Transparent are most to be successful id the patient (recipient) and the kidney donor are closely related because a patient's body tends to rejects any tissues which not it own. This tendency or less severe if the donor and patient are close blood relatives. The ideal; donor patient relationship is that of identical twins. Drugs are also to suppress the body's rejection reactions.

Kidney transplant is a better remedy for person suffering from a kidney failure than a dialysis. However, the whole procedure is a relatively expensive. Besides the expense, a suitable, person whose tissues are similar to the patient has to be found.

Many people denote their kidney and other organs for transplant purposes. These organs are numerous from the bodies as soon as potential, die donors die and transplanted into the bodies of the recipients. A healthy living person can denote a kidney without adverse effect [5]

II. MATERIAL AND METHODS

The data used in this study was obtained from the department of clinical pathology university of Maiduguri teaching hospital (UMTH). The data is result of serum renal biochemistry carried out on the blood sample of ten (10) individuals randomly selected with renal related problem

The method used in this research was analysis of variance. The main stages in the application of this method include among others are: that the study variable or unit is replicated so as to help obtained an estimate of the

experimental error; and precise estimate of the variable effects. Randomization is the cornerstone underlying the use of this method as it helps validate the following: eliminate bias, subjectivity and distribute evenly the extraneous effect.

Having observed the above crucial points the next step is to make sure that these assumptions are absolutely satisfied: normality, independence, homoscedasticity, additivity and zero summation of the error effect. If all these are met; one proceeds to specify the model, and the estimate the parameters contained in the model [6].

The models adopted in this study are as follows:

$X_{ij}=\mu+\alpha_i+\epsilon_{ij}$ (1)

Where

X_{ij} is the j^{th} replicate of ith treatment/ variable

μ is the grand mean irrespective of the treatment effect

α_i is the treatment effect

ϵ_{ij} is the random error associated with observing X_{ij}

$y_{ij}= \mu+\delta_i+\beta_j+\varepsilon_{ij}$ (2)

Where

y_{ij} is the

μ is the grand mean irrespective of the treatment effect

δ_i is the effect of factor one

β_j is the effect of factor two

ε_{ij} random error associated with observing y_{ij}

Having specified and estimated the parametres of the models one then set up the anova table and then make inference or pass judgment.

Other test are also carried out to improve the results of the study, these are precision of the study: by precision we mean in simpler term the closeness to with which it measures or serve to estimate the quantity being investigated; which is obtained by dividing the variance per observation by the number of observations, the reciprocal then gives the measure of precision. The relative efficiency of the designs are also measured to decide on which of the two is more efficient and is obtained by taking the ratio of the two designs. Coefficient of determination was also calculated to measure the amount of variation in factor one which are explained by factor two. Post-hoc test are also carried out to identify which of the treatment has a severe effect on the renal function.

III. RESULTS AND DISCUSSIONS

Table 1

TREATMENTS					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	178257.788	5	35651.558	481.312	.000
Within Groups	3999.865	54	74.072		
Total	182257.652	59			

Table 1.1: Dependent Variable:TREATMENTS

		95% Confidence Interval	
Mean	Std. Error	Lower Bound	Upper Bound
64.025	1.090	46	.000

Table 2

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Model	425003.806[a]	15	28333.587	397.710	.000
FACTOR1	178257.788	5	35651.557	500.430	.000
FACTOR2	793.981	9	88.220	1.238	.297
Error	3205.884	45	71.242		
Total	428209.690	60			

a. R Squared = .993 (Adjusted R Squared = .990)

Table 2.1: Levene's Test of Equality of Error Variances[a]

Dependent Variable: TREATMENTS

F	df1	df2	Sig.
4.510	13	46	.000

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

Table 3: Multiple Comparisons

TREATMENTS
LSD

(I) FACTOR1	(J) FACTOR1	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1	2	132.40000*	3.84894	.000	124.6833	140.1167
	3	38.70000*	3.84894	.000	30.9833	46.4167
	4	119.50000*	3.84894	.000	111.7833	127.2167
	5	131.55000*	3.84894	.000	123.8333	139.2667
	6	25.90000*	3.84894	.000	18.1833	33.6167
2	1	-132.40000*	3.84894	.000	-140.1167	-124.6833
	3	-93.70000*	3.84894	.000	-101.4167	-85.9833
	4	-12.90000*	3.84894	.001	-20.6167	-5.1833
	5	-.85000	3.84894	.826	-8.5667	6.8667
	6	-106.50000*	3.84894	.000	-114.2167	-98.7833
3	1	-38.70000*	3.84894	.000	-46.4167	-30.9833
	2	93.70000*	3.84894	.000	85.9833	101.4167
	4	80.80000*	3.84894	.000	73.0833	88.5167
	5	92.85000*	3.84894	.000	85.1333	100.5667
	6	-12.80000*	3.84894	.002	-20.5167	-5.0833
4	1	-119.50000*	3.84894	.000	-127.2167	-111.7833
	2	12.90000*	3.84894	.001	5.1833	20.6167
	3	-80.80000*	3.84894	.000	-88.5167	-73.0833
	5	12.05000*	3.84894	.003	4.3333	19.7667
	6	-93.60000*	3.84894	.000	-101.3167	-85.8833
5	1	-131.55000*	3.84894	.000	-139.2667	-123.8333
	2	.85000	3.84894	.826	-6.8667	8.5667
	3	-92.85000*	3.84894	.000	-100.5667	-85.1333
	4	-12.05000*	3.84894	.003	-19.7667	-4.3333
	6	-105.65000*	3.84894	.000	-113.3667	-97.9333
6	1	-25.90000*	3.84894	.000	-33.6167	-18.1833
	2	106.50000*	3.84894	.000	98.7833	114.2167
	3	12.80000*	3.84894	.002	5.0833	20.5167
	4	93.60000*	3.84894	.000	85.8833	101.3167
	5	105.65000*	3.84894	.000	97.9333	113.3667

*. The mean difference is significant at the 0.05 level.

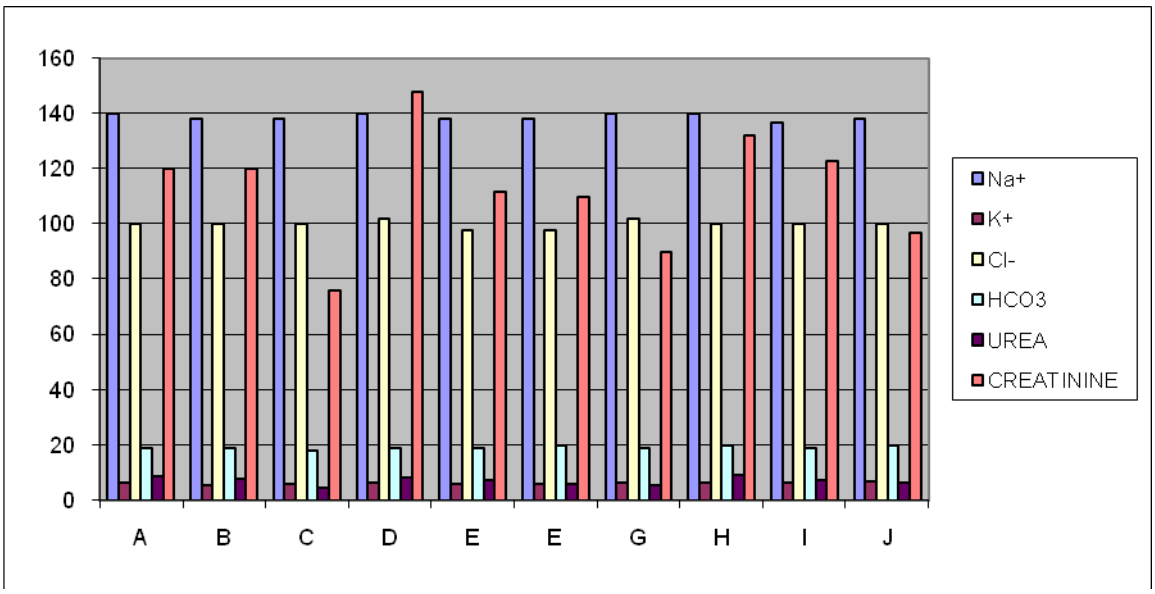

Figure 1

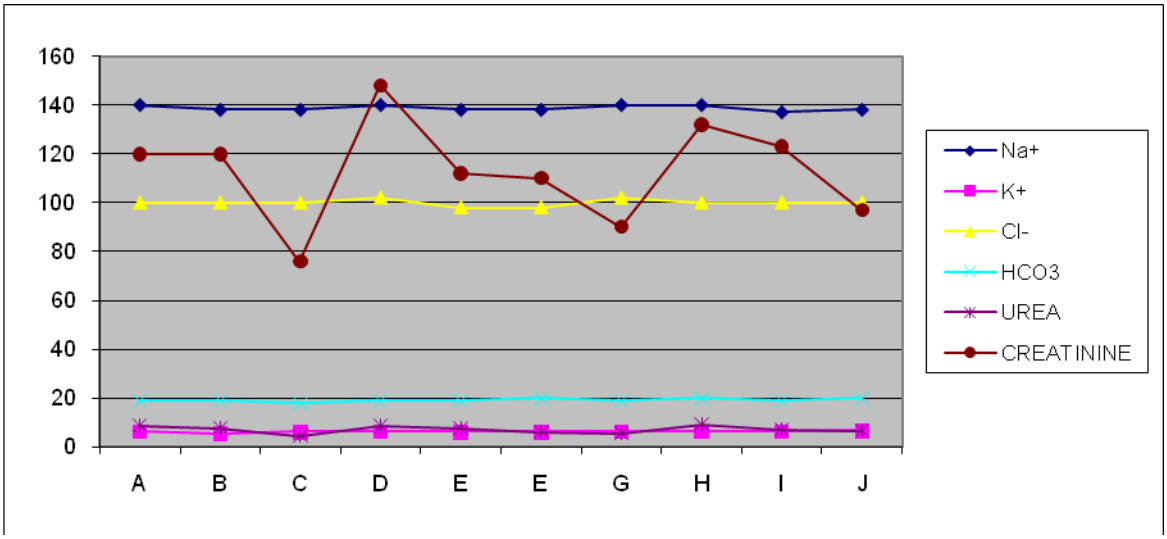

Figure 2.

Table 1.0 presents the results of the one-factor analysis of variance; indicating that there is significant difference between factor one: meaning that the concentration of these chemical substances (Na^+, k^+, Cl^-, HCO_3, Urea, Creatinine) found in the blood and body is significant on the renal function.
Table 1.1 gives the results of the descriptive statistic for factor one consisting of the mean, standard error and 95% confidence interval for the grand mean for factor 1; indicating a significant value.

Table 2.0 contains the results of the two factor analysis of variance from which it is obvious that the model is significant factor 1is also significant, while factor 2 is not at 5% level of significant; meaning thereby that there is significant effect of the level of concentration of the substance found of the blood (Na^+, k^+, Cl^-, HCO_3, Urea, Creatinine) with respect to the renal function while by insignificance of factor 2 means that there is no significant difference in the concentration of the substances (Na^+, k^+, Cl^-, HCO_3, Urea, Creatinine) as far as individual is concerned.

The post –hoc test carried out to identify which of the factor 1 (Na^+, k^+, Cl^-, HCO_3, Urea, Creatinine) has severe effect on the renal function as presented in table 2.1, indicates that they all have severe effect as far as the renal function is concerned. Fig. 1 and 2 presents the descriptive statistics of a multiple bar chart and a

simple plots; both indicating a variation in the individuals concentration level of Creatinine, and K^+, with no significant variation in the concentration levels of individuals Cl^-, urea and HCO_3

The precision of the test calculated gives a value of 0.842 (84.2%) which means it has preferably measured or served to estimate the desired objective of the study up to 84.2%. a relative efficiency of 0.962 was obtained between the two designs, and since it is less than one (0.962<1) it means that Two Factor Analysis of Variance is more significant that the one factor analysis of variance; and that about 99.3% of variations in factor 1 is explained by the variations in factor 2.

IV. CONCLUSION

The research aimed at finding out the effect of the concentration of the chemical substances (Na^+, K^+, Cl^- HCO_3, Urea, Creatinine) found in the body and the blood on the renal function both in individual and combined state. This is in a view to assess the function ability of the renal system; being the body's filtrating system.

From the discussion of the findings of the results presented in the preceding section; it is obvious that the concentration of the chemical substances (Na^+, k^+, Cl^-, HCO_3, Urea, Creatinine) in the body and the blood affects the renal system severely both in individual and combined state; that renal failure or rather renal problem is normally distributed as far as human individuals is concerned.

V. RECOMMENDATION

Sequel to the findings, discussion and conclusion of the results of the study, the following are recommended:

People are generally advice to avoid consuming food substances that are too salty, portentous and likes and should drink enough water first thing in the morning as it help in with renal function.

Regular serum electrolyte test should be carried out to ascertain the levels of Na+, k+, Cl HCO_3, Urea, Creatinine; in the blood and that medical practitioners should endeavour to give adequate public campaign and enlightenment on renal and renal related problems.

Government in it responsibility in providing basic and affordable healthcare services endeavour to establish kidney centre in localities

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