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Assessment of Kidney and Liver Functions in Post COVID-19-Vaccinated Individuals in Rivers State, Nigeria

Obisike, U. A. [a*], Tamuno, C. B. [a], Waribo, H. A. [a] and Elekima, I. [a]

[a] Department of Clinical Chemistry and Molecular Diagnostics, Faculty of Medical Laboratory Science, Rivers State University, Port Harcourt, Nigeria.

Authors' contributions

This work was carried out in collaboration among all authors. Author OUA designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Author TCB managed the analyses and authors WHA and EI managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Aim: To assess kidney and liver functions in COVID-19-vaccinated individuals in Rivers State, Nigeria
Study Design: Cross-sectional Observational study.
Place and Duration of Study: Polar Precision Laboratories, Port Harcourt, Nigeria, between May and November 2022.
Methodology: This study was carried out on 50 apparently healthy subjects; both males and females of which 30 were COVID-19-vaccinated subjects and 20 were non-vaccinated, which were used as control subjects. The studied subjects had previously received three types of vaccines:

**Corresponding author: E-mail: obisike.uchechukwu@ust.edu.ng;*

AstraZeneca, Pfizer and Moderna. The study analyzed kidney function parameters: [Creatinine (Cr), Urea(U), Sodium (Na^+), Potassium (K^+), Chloride (Cl^-) and Bicarbonate ($HCO3^-$)] and liver function parameters: [aspartate amino transaminase (AST), alanine amino transaminase (ALT), alkaline phosphatase (ALP), Total Protein, Albumin, Direct bilirubin and Total bilirubin], using colorimetric methods except for ALP in which kinetic method was employed. Statistical analysis of the data obtained was done using GraphPad Prism version 9.0.4 of Apple Macintosh HD Big Sur (version 11.0) and p values < 0.05 were considered statistically significant.

Results: It was observed that the mean ± SD for COVID-19 vaccinated subjects and non-vaccinated subjects were as follows: for renal function indices: Urea: 4.11 ± 1.03mmol/l and 3.95 ± 0.73mmol/l respectively, Cr: 100.7 ± 21.04mmol/l and 98.25 ± 15.33mmol/l respectively. Na+: 138.9 ± 4.80mmol/l and 142.7 ±3.65mmol/l respectively. K^+: 4.49±0.63mmol/l and 3.17 ±0.20mmol/l respectively. Cl-: 101.0 ± 4.21mmol/l and 104.1 ± 3.14mmol/l respectively. HCO3-: 25.88 ± 3.32mmol/l and 26.74 ± 2.07mmol/l respectively. The result for liver function parameters were as follows: AST: 7.36 ± 5.16U/l and 8.08 ± 2.99U/l respectively, ALT: 2.90 ± 0.90U/l and 2.20 ± 0.62U/l respectively. ALP: 116.9 ± 36.30U/l and 118.5 ± 32.52U/l respectively. Alb.: 40.95 ± 2.49g/l and 38.90 ± 4.22g/l respectively. TP: 65.88 ± 3.40g/l and 68.05 ± 3.88g/l respectively. D.Bil: 2.147 ± 0.780µmol/l and 2.185 ± 0.502µmol/l respectively. T.Bil.: 7.31 ± 2.33µmol/l and 7.q3 ± 1.52µmol/l respectively. Comparison between the kidney function parameters for COVID-19 vaccinated and non-vaccinated subjects was not significant ($p > 0.05$) for urea, creatinine and HCO^{3-}, but was significant ($p < 0.05$) for AST, ALP, direct, total bilirubin, ALT, Alb and total protein.

Conclusion: From this study, it can be inferred that the COVID-19 vaccine had no negative effect on the liver and kidneys, but merely altered some biochemical parameters.

Keywords: Renal parameters; hepatic parameters; COVID-19 vaccination; Port Harcourt.

1. INTRODUCTION

Reports from several clinical studies have shown that vaccines developed against COVID-19 have the potential and efficacy to protect individuals from the effects of the disease, however the side effects of these vaccines are yet to be well understood; thus, the side effects are occasionally overlooked [1] Several studies have given reports on the development of kidney diseases [2] and liver diseases [3,4] after COVID-19 vaccinations.

In the past few years, there was a serious pandemic hit worldwide by the coronavirus disease (commonly called COVID-19), which presented several challenges on the livelihood of individuals, health systems and socioeconomic aspects of life [5]. These challenges may be attributed to the uniqueness and dynamics in which the disease is transmitted, as well as the symptoms and immune response of associated with the disease [6].

Coronaviruses belong to a large family of single-stranded RNA, enveloped and non-segmented positive-sense viruses capable of infecting animals and humans, thereby causing diseases of the respiratory and gastrointestinal tracts, liver, and nerves [7]. They are the largest known RNA viruses to have existed, and are grouped into four genera, including alpha-coronaviruses, beta-coronaviruses, gamma-coronaviruses, and delta-coronaviruses [8]. About six different types of human coronaviruses have been identified which include alphacoronaviruses such as NL63 and 229E, beta coronaviruses such as OC43, and HKU1, severe acute respiratory syndrome coronavirus (SARS-CoV), and Middle East respiratory syndrome coronavirus (MERS-CoV) [9,10]. In humans also, a periodic emergence of new types of coronaviruses have been reported, and this may be attributed to the wide-spread and high prevalence of the coronaviruses; it may also be because these viruses have a large genetic diversity, with their genomes undergoing regular recombination, and also due to an increase in human to animal interface activities [11,12].

Coronaviruses have their genome wrapped by a capsid that is shaped like a helix, and an envelope made of lipoprotein; the envelope contains several spicules of glycoprotein making the virus appear like a crown [13]. After infecting humans, coronaviruses undergo an incubation of about 2 to 5 days, after which they induce various diseases such as common cold (due to infection of the upper respiratory tract), liver disease, enteric fever or enteritis, and neurological diseases. Also, pneumonia and

bronchitis may occur due to infection of the lower respiratory tract, and severe acute respiratory syndrome (SARS) [14,15].

Most of the infections caused by coronaviruses in humans seem to be mild, however over ten thousand cases within the past two decades were caused by the two beta coronaviruses namely SARS-CoV-2 and Middle East respiratory syndrome coronavirus [16] with a death rate of 10 percent and 37 percent respectively [12,17]. The incubation period and the clinical course of MERS are like that of SARS, except that a larger percentage of cases progress to respiratory deterioration and distress in MERS [13].

Infection with the SARS-CoV-2 has been reported to induce alterations in the physiology of the human body including hematological, neurological, cardiac, and renal alterations [18,19]. Some of the reported changes in haematological parameters include changes in platelet, white blood cell, and hemoglobin level. Also, some alterations in the coagulation/fibrinolytic pathway have been reported [18].

Due to the negative effects of the Coronavirus pandemic globally, health sectors, academia, and different governments came together to develop and test various vaccines at an unprecedented speed to fight and prevent the spread of the virus and bring the world back to normal. Some of the vaccines developed include Pfizer, Moderna, and AstraZeneca [20]. These vaccines strengthen the immune system by using the body's inherent defense mechanisms to boost resistance to specific disease agents. They generate memory cells, which teach the body's immune infrastructure to rapidly-produce antibodies in the same way that it does when natural infection occurs [21]. However, some side effects have been reported from the use of these vaccines, including pain, swelling, and erythema at the local injection site [22].

As drugs, the vaccines are metabolized by the liver, and excreted by the kidneys, and may therefore exert deleterious effects on these organs, which would be a serious public health issue, as millions of people globally have taken a type of the covid-19 vaccines. Thus, it is important to carry out this study so as to assess the functional capacity of these important organs in individuals who have been administered with COVID-19 vaccine.

2. MATERIALS AND METHODS

2.1 Study Area

This study was carried out in Rivers State, Nigeria. Rivers State is a state in the Niger Delta region of Nigeria. Created in 1967, when it was split from the former Eastern Region, it borders around Imo, Abia and Anambra states to the North, Akwa Ibom state to the East and Bayelsa and Delta states to the West. The state capital, Port Harcourt, is a metropolis that is considered the commercial center of the Nigeria oil Industry. As a multicultural, multitribal region, Rivers State has over 26 distinct groups and about 23 local government areas with an estimated population of over 7 million people.

2.2 Study Population and Design

This is a cross-sectional study, where a convenient sample size of 50 apparently healthy subjects between the ages of 18-70 years were recruited for this study; out of which 30 subjects are those who have received the COVID-19 vaccine, while the remaining 20 subjects were control subjects (those who have not received the COVID-19 vaccine). A well-structured questionnaire was used to gather relevant information on age, sex, type of COVID-19 vaccine taken, number of shots taken and the health status of the subjects.

2.3 Inclusion Criteria

The subjects included in the study are apparently healthy, within the ages of 18-60 years. The test subjects were those who have received the COVID-19 vaccine. The control subjects are those who have not received the COVID-19 vaccine.

2.4 Exclusion Criteria

Subjects with haematological disorders, kidney disease, cardiovascular disease and diabetes mellitus were excluded from this study.

2.5 Blood Sample Collection

About 8 ml of venous blood sample was collected from each subject using sterile hypodermic syringes and needles and was dispensed into plain bottles; the sample was spun, and the serum was separated and used for the analysis of kidney and liver parameters.

2.6 Sample Analysis

2.6.1 Determination of creatinine level in plasma

Method of assay: buffered kinetic Jaffe reaction without deproteinization method [23].

Assay principle: Creatinine reacts with picric acid under alkaline condition to form a yellow-red complex. Absorbance of the color produced, measured at a wavelength 492nm, is directly proportional to creatinine concentration in the sample.

Creatinine + picrate - yellow-red complex

2.6.2 Determination of plasma urea level

Method of assay: Urase colorimetric method [24].

Assay principle: The reaction involved in the assay system is as follows:

Urea is hydrolyzed in the presence of water and urease to produce ammonia and Bicarbonate.

Urea + H_2O ------- 2NH3 + CO_3

The free ammonia in an alkaline pH and in the presence of indicator forms coloured complex proportional to the urea concentration in the specimen.

2.6.3 Determination of plasma sodium level

Method of assay: Colorimetric method [25]

Assay principle: The present method is based on reaction of sodium with a selective chromogen producing a chromophore whose absorbance varies directly as the concentration of sodium in the test specimen.

2.6.4 Determination of plasma potassium level

Method of assay: Turbidimetric Tetraphenylborate method [26].

Assay principle: At an alkaline pH potassium ion and TPB form a turbid emulsion, the increase of which can be measured quantitatively in photometer at 578nm.

2.6.5 Determination of plasma bicarbonate level

Method of assay: colorimetric method [27].

Assay principle: The chloride ion displaces thiocyanate from non-ionized mercuric thiocyanate to form Mercuric chloride and thiocyanate ions. The released thiocyanate ions react with ferric ions to form a color complex that absorbs light at 480 nm. The intensity of the colour produced is directly proportional to the chloride concentration.

2.6.6 Determination of Plasma Chloride level

Method of assay: colorimetric method [28].

Assay principle: Colomeric test for the quantitative determination of Bicarbonate (HCO3-) in serum and plasma:

Phophoenolpyruvate + Bibarbonate + NADH - Phosphate + Malate + NAD+

2.6.7 Determination of plasma aspartate aminotransferase (AST) & alanine aminotransferase (ALT) level

Method of assay: colorimetric method [29].

Assay principle for AST: The reaction involved in the assay system is as follows:

The amino group is enzymatically transferred by AST present in the sample from L-aspartate to the carbon atom of 2-oxoglutarate yielding oxaloacetate and L-glutamate.

L-Aspartate Oxaloacetate
2-Oxoglutrate L-Glutamate

AST activity is measured by monitoring the concentration of oxaloacetate hydrazone formed with 2,4-dinitrophenylhydrazine.

Assay principle for ALT: This reaction involved in the assay system is as follows:

The amino group is enzymatically transferred by ALT present in the sample from alanine to the carbon atom of 2-oxoglutarate yielding pyruvite and L-glutamate

L-Alanine + 2-Oxoglutarate - Pyruvate + L-Glutatamte

ALT activity is measured by monitoring the concentration of pyruvate hydrazone formed with 2,4-dinitrophenylhydrazine.

2.6.8 Determination of alkaline phosphatase (ALP) plasma level

Method of assay: Kinetic method [30]

2.6.9 Determination of plasma bilirubin level

Method of assay: Colorimetric Diaxo method [31].

Assay principle: The total bilirubin concentration is determined in presence of caffeine by the reaction with diazotized sulphanilic acid to produce an intensely coloured diazo dye (560-600 nm). The intensity of colourin this dye formed is proportional to the concentration of total bilirubin.

Direct bilirubin is determined in absence of caffeine by the direct reaction with diazotized sulphanilic acid to form re-coloured azobilirubin, the colour intensity of which measured at 546 nm is proportional to the concentration of the direct bilirubin in the sample.

Sulfanilic acid + $NaNO_2$ - Diazotized sulfanilic acid

Bilirubin + Diazotized Azobilirubin

2.6.10 Determination of total protein in plasma

Method of assay: Colorimetric (Biuret reagent) method [32].

2.6.11 Determination of plasma albumin

Method of Assay: modified Bromocresol Green colorimetric method [31].

2.7 Statistical Analysis

GraphPad Prism version 9.0.4 of Apple Macintosh HD Big Sur (version 11.0) statistical package was used for data analysis. Descriptive statistical tools such as mean & SD were used. Students independent sample t-test and ANOVA were respectively used to compare means of two and more than two groups for inferential evaluation. Pearson ranked correlation was used to evaluate relationships between values in two groups. Bar and Pie charts were used to present demographic information. The probability (p) value less than 0.05 ($P<0.05$) was used and considered statistically significant.

3. RESULTS AND DISCUSSION

This study assessed kidney and liver functions in COVID-19-vaccinated individuals in Rivers State, Nigeria. The mean AST and ALP level of the test subjects were not significantly different when compared with that of the control. With respect to the liver. AST is a marker of hepatocellular injury, while ALP is a marker of cholestasis [33]. Therefore, the result obtained from this study may be attributed to the fact that the COVID-19 vaccines may have had no potential of inducing hepatocellular injury or cholestasis. The report disagrees with that of Sohrabi et al. [4] which noted an increase in the hepatic enzymes after COVID-19 vaccination in a case report. However, the mean ALT level of the test subjects was significantly higher when compared with that of the control. Since the AST level was not elevated, this elevated ALT level may suggest that the COVID-19 vaccine may have induced conditions other than hepatocellular injury, such as non-alcohol fatty liver (which usually triggers and increases ALT, with normal AST levels). The report from this study agrees with that from a case report by Mann et al. [3] and Sohrabi et al. [4], which noted elevated ALT level in COVID-19 vaccinated individuals.

Table 1. Test subjects based on number and type of shots

Test subjects based on shots	Number of Subjects
One shot	3
Two shots	22
Three shots	5
Based on type of vaccine received	
AstraZeneca	17
Astra & Pfizer	3
Moderna	10

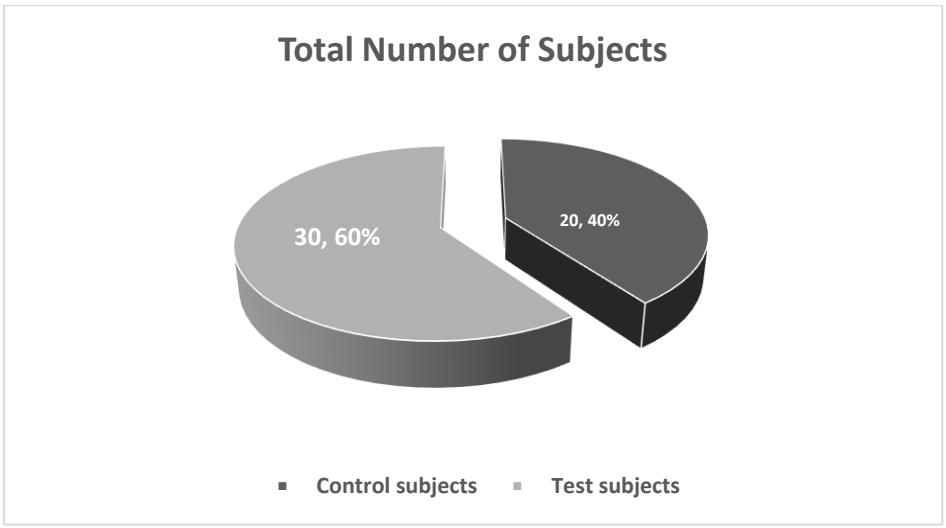

Fig. 1. Demography: Total number of subjects

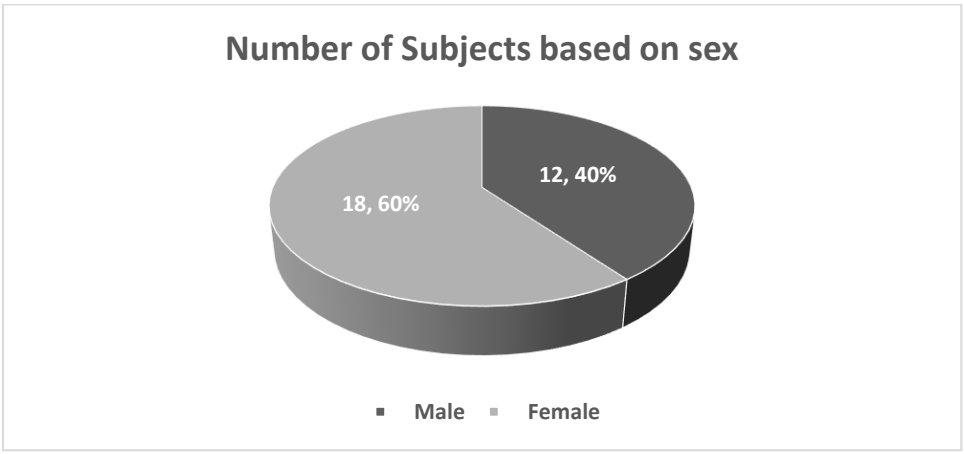

Fig. 2. Demography: Number of subjects based on sex

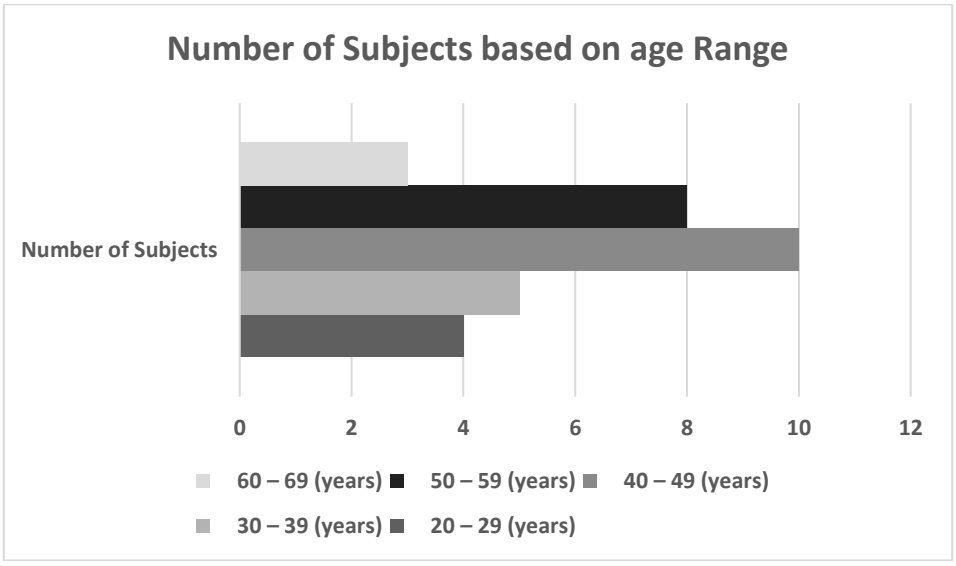

Fig. 3. Demography: Number of subjects based on age range

Table 2. Liver function parameters for COVID-19 vaccinated and non-vaccinated

Groups	AST(U/l)	ALT (U/l)	ALP (U/l)	Albumin (g/l)	Total protein (g/l)	Direct Bilirubin (μmol/l)	Total Bilirubin (μmol/l)
Control (N-20)	8.08±2.99	2.20±0.62	118.5±32.52	38.90±4.22	68.05±3.88	2.185±0.502	7.13±1.52
Test (N-30)	7.36±5.16	2.90±0.90	116.9±36.13	40.95±2.49	65.88±3.40	2.147±0.787	7.31±2.33
P-value	0.577	0.003	0.872	0.0356	0.0422	0.848	0.758
Remark	**NS**	**S**	**NS**	**S**	**S**	**NS**	**NS**

S – Significant, NS – Not significant at p < 0.05., AST-Aspartate transaminase, ALT-Alanine transaminase, ALP-Alkaline phosphatase

Table 3. Kidney function parameters for COVID-19 vaccinated and non-vaccinated

Groups	Urea (mmol/l)	Cr (mmol/l)	Na^+ (mmol/l)	K^+ (mmol/l)	Cl^-(mmol/l)	HCO_3^- (mmol/l)
Control (N-20)	3.95±0.73	98.25±15.33	142.7±3.65	3.17±0.20	104.1±3.14	26.74±2.07
Test (N-30)	4.11±1.03	104.7±21.04	136.9±4.80	4.49±0.63	101.0±4.21	25.88±3.32
P-value	0.548	0.246	<0.0001	<0.0001	0.0066	0.3100
Remark	**NS**	**NS**	**S**	**S**	**S**	**NS**

S – Significant, NS – Not significant at p < 0.05., Cr – Creatinine, Na^+ - Sodium ion, K^+- Potassium ion, Cl^-- Chloride ion, HCO_3^- - Bicarbonate ion

Table 4. Liver function parameters for COVID-19 vaccinated subjects grouped based on the type of vaccine received

Groups	AST (U/l)	ALT (U/l)	ALP (U/l)	Albumin (g/l)	Total protein (g/l)	Direct Bilirubin (μmol/l)	Total Bilirubin (μmol/l)
AstraZeneca (N-17)	7.41±6.01	2.87±0.84	113.2±35.36	41.06±2.92	65.89±3.32	2.22±0.84	7.48±2.67
Astra & Pfizer(N-3)	3.63±0.23	2.53±0.40	148.4 ±66.6	39.90±2.40	64.17±2.90	2.30±0.36	6.76±0.55
Moderna (N-10)	8.41±3.95	3.07±1.10	113.7±25.04	41.09±1.74	66.37±3.80	1.97±0.80	7.18±2.11
F-value	0.989	0.4180	1.297	0.2840	0.4664	0.3724	0.1375
P-value	0.385	0.6625	0.289	0.7550	0.6322	0.6926	0.8721
Remark	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

S – Significant, NS – Not significant at p < 0.05., AST-Aspartate transaminase, ALT-Alanine transaminase, ALP-Alkaline phosphatase

Table 5. Kidney function parameters for COVID-19 vaccinated subjects grouped based on the type of vaccine received

Groups	Urea (mmol/l)	Cr (mmol/l)	Na^+ (mmol/l)	K^+ (mmol/l)	Cl^-(mmol/l)	HCO_3^- (mmol/l)
AstraZeneca (N-17)	3.73±0.52	103.3±19.22	136.7±4.86	4.42±0.79	100.4±4.74	26.08±3.38
Astra Pfizer(N-3)	5.50±2.17[1]	113.0±31.80	137.3±3.28	4.83±0.55	104.7±2.44	22.43±1.45
Moderna (N-10)	4.35±0.96	104.6±22.77	137.3±5.46	4.51±0.42	100.8±3.30	26.58±3.35
F-value	5.310	0.2559	0.0512	0.5033	1.331	1.997
P-value	0.0114	0.7761	0.9501	0.6101	0.281	0.155
Remark	**S**	**NS**	**NS**	**NS**	**NS**	**NS**

S – Significant, NS – Not significant at p < 0.05. 1- significant when compared with mean for AstraZeneca group (Tukey's multiple comparison test). Cr – Creatinine, Na^+ - Sodium ion, K^+- Potassium ion, Cl^-- Chloride ion, HCO_3^- - Bicarbonate ion

Table 6. Liver function parameters for COVID-19 vaccinated subjects grouped based on the number of vaccine shots received

Groups	AST (U/l)	ALT (U/l)	ALP (U/l)	Alb (g/l)	TP (g/l)	D.Bil. (μmol/l)	T.Bil. (μmol/l)
One shot (N-3)	6.90±3.82	3.63±1.44	137.6±52.55	42.07±1.66	64.03±4.04	2.73±0.83	8.60±2.27
Two shots (N-22)	8.10±5.66	2.93±0.84	112.5±27.59	41.15±2.61	66.06±3.04	2.05±0.84	7.29±2.57
Three shots (N-5)	4.42±1.84	2.32±0.49	123.8±59.99	39.40±1.87	66.20±4.92	2.20±0.29	6.64±0.68
F-value	1.053	2.221	0.737	1.380	0.476	0.9935	0.6482
P-value	0.3627	0.1280	0.487	0.2688	0.626	0.3834	0.5309
Remark	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

S – Significant, NS – Not significant at p < 0.05., AST-Aspartate transaminase, ALT-Alanine transaminase, ALP-Alkaline phosphatase

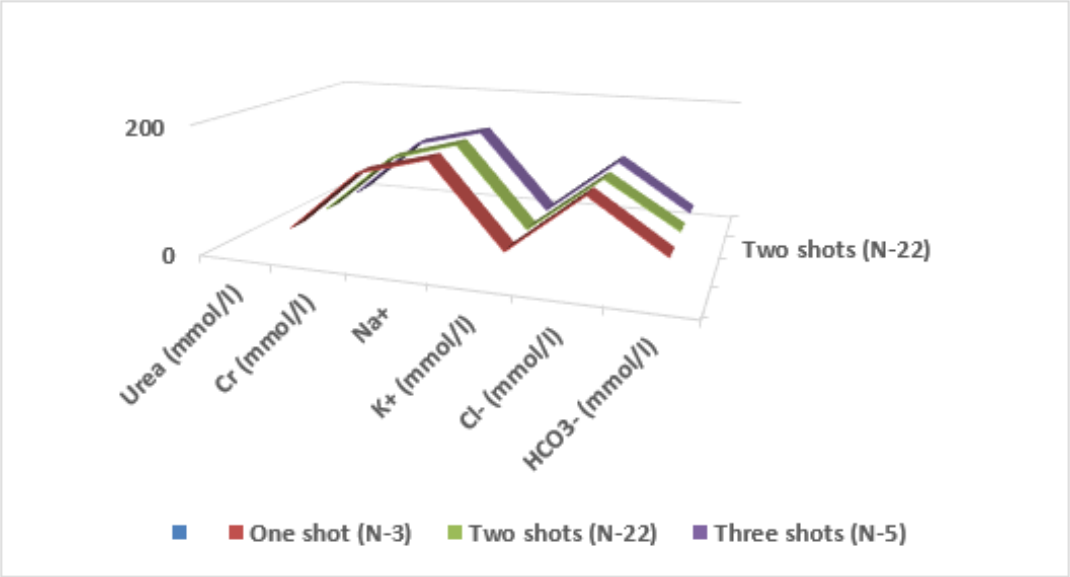

Fig. 4. Kidney function parameters for COVID-19 vaccinated subjects grouped based on the number of vaccine shots received

Table 7. Liver function parameters for COVID-19 vaccinated subjects grouped based on age range

Groups	AST (U/l)	ALT (U/l)	ALP (U/l)	Albumin (g/l)	Total protein (g/l)	Direct Bilirubin (μmol/l)	Total Bilirubin (μmol/l)
20-29 yrs (N-4)	7.67±4.54	3.15±1.43	121.8±34.10	40.35±4.94	67.10±2.12	2.05±0.99	7.22±2.42
30-39 yrs (N-5)	9.42±6.13	9.42±6.13	96.30±23.90	41.50±2.48	64.28±3.86	2.18±1.02	7.28±1.64
40-49yrs(N-10)	8.35±4.47	2.96±0.55	104.1±33.00	41.85±1.88	66.05±3.02	2.31±0.79	7.92±3.48
50-59 yrs (N-8)	6.00±2.12	2.65±0.46	39.60±1.68[1,3]	39.60±1.68	66.34±4.65	2.13±0.39	6.90±1.33
60-69 yrs (N-3)	3.90±1.53	3.86±1.85	130.4±8.13[4]	41.47±1.32	65.13±1.71	1.70±1.24	6.56±0.68
F-value	0.7435	2.555	12.50	1.077	0.446	0.332	0.2790
P-value	0.5714	0.0638	<0.0001	0.388	0.773	0.853	0.8888
Remark	**NS**	**NS**	**S**	**NS**	**NS**	**NS**	**NS**

S – Significant, NS – Not significant at p < 0.05. 1, 3 & 4- significant when compared with means for the group numbers listed (Tukey's multiple comparison test). AST-Aspartate transaminase, ALT-Alanine transaminase, ALP-Alkaline phosphatase

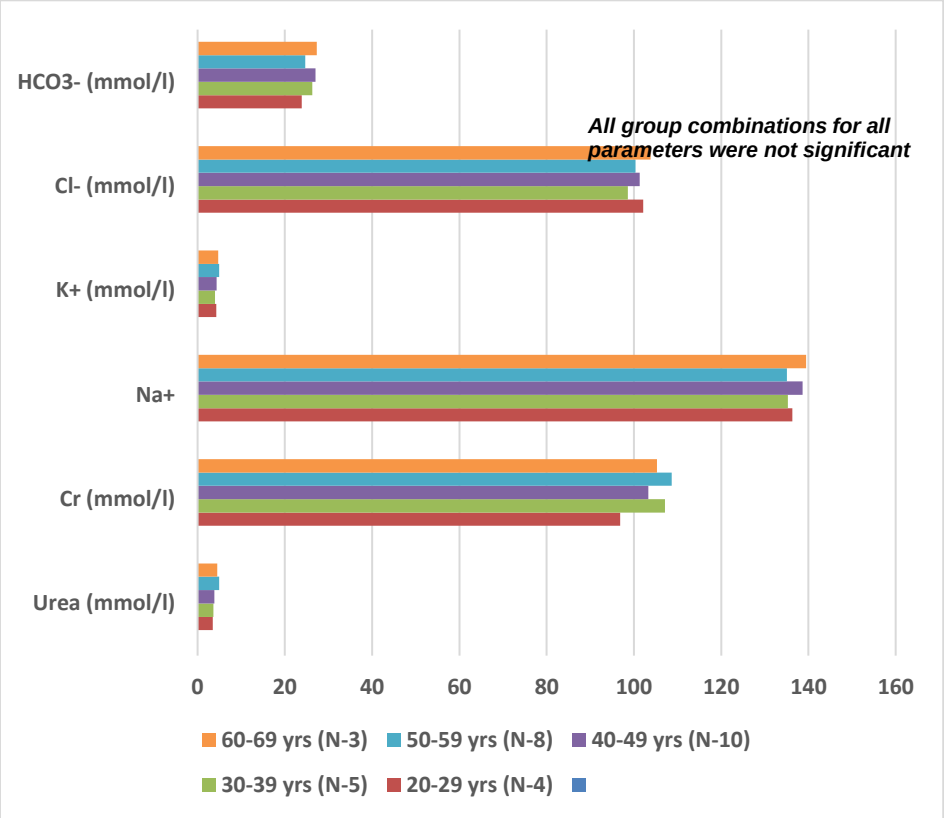

Fig. 5. Kidney function parameters for COVID-19 vaccinated subjects grouped based on age range

Table 8. Liver function parameters for COVID-19 vaccinated subjects grouped based on sex

Groups	AST (U/l)	ALT (U/l)	ALP (U/l)	Alb (g/l)	TP (g/l)	D. Bil. (μmol/l)	T. Bil. (μmol/l)
Female (N=18)	6.02±3.36	2.75±0.93	122.1±43.37	40.22±2.62	66.34±3.17	1.99±0.77	7.08±2.43
Male (N=12)	9.37±6.73	3.13±0.83	108.9±20.50	42.06±1.86	65.19±3.75	2.37±0.77	7.65±2.24
P-value	0.0815	0.2606	0.3346	0.0451	0.3748	0.2001	0.5183
Remark	**NS**	**NS**	**NS**	**S**	**NS**	**NS**	**NS**

S – Significant, NS – Not significant at p < 0.05.AST-Aspartate transaminase, ALT-Alanine transaminase, ALP-Alkaline phosphatase

Table 9. Kidney function parameters for COVID-19 vaccinated subjects grouped based sex

Groups	Urea (mmol/l)	Cr (mmol/l)	Na^+ (mmol/l)	K^+ (mmol/l)	Cl^- (mmol/l)	HCO_3^- (mmol/l)
Female (N=18)	4.47±1.17	99.61±21.35	136.4±4.54	4.60±0.62	101.0±3.91	25.44±3.38
Male (N=12)	3.58±0.39	112.3±18.90	137.8±5.25	4.33±0.64	100.9±4.82	26.54±0.93
P-value	0.0182	0.1062	0.4272	0.2561	0.9451	0.3847
Remark	**S**	**NS**	**NS**	**NS**	**NS**	**NS**

S – Significant, NS – Not significant at p < 0.05. Cr – Creatinine, Na^+ - Sodium ion, K^+- Potassium ion, Cl^--Chloride ion, HCO_3^- - Bicarbonate ion

Likewise, the significantly elevated albumin level noted in COVID-19 vaccinated individuals and the significantly decreased total protein level noted in the test subjects may be attributed to conditions other than kidney disease. This report disagrees with that from a similar study conducted by Kudair and Al-Hussary [34] which noted a significant decrease in plasma albumin

level as an effect of COVID-19 vaccination. A non-significant difference in total and direct bilirubin levels obtained from the study is an affirmation that Cholestasis was not induced in the covid-19 subjects. An increase in (particularly) direct bilirubin is also an indication of cholestasis [34], where the conjugated bilirubin is unable to flow out of the bile duct, thus regurgitating into the blood circulation and resulting in an increased level [33].

The study noted a non-significant change in urea and creatinine level in the test subjects when compared with the control subjects. Physiologically, the kidneys filter and excrete substances or waste products of metabolism including creatinine and urea [35]. However, the presence of renal impairment may affect this physiological function of the kidneys, which may result in the accumulation of wastes (particularly creatinine and urea) in the circulation [36]. Therefore, the non-significant difference in urea and creatinine between the test subjects and the controls, may be indicative of the fact that the COVID-19 vaccine did not reveal a nephrotoxic potential. Contrary to this report, several other reports have established the relationship between COVID-19 vaccination and renal dysfunction [2,35,37]. The level of the electrolytes including sodium ions, potassium ions and chloride ions were elevated in the test subjects when compared with the control subjects. On the contrary, there was a non-significant change in bicarbonate ion level between the control and test subjects. As previously stated, the significantly elevated albumin level in the test subjects may be attributed to conditions other than kidney disease.

The different types of the COVID-19 vaccine (Moderna, Astra & Pfizer and AstraZeneca) received had no significant effect on the kidney and liver function parameters, except for urea level that were significantly elevated in the group that received the Astra & Pfizer vaccine when compared with the group that received AstraZeneca. The Astra & Pfizer vaccine is a messenger RNA vaccine, while AstraZeneca is a viral vector vaccine [38]; this variation might be responsible for the different effect that was noted in the different groups. From this study it was revealed that the COVID-19 vaccines were received at different shots or doses; one shot, two shots, or three shots. Most brands of COVID-19 vaccine require two doses of varying intervals for full protection. However, some other brands require a single dose for full protection against the virus [39]. However, the number of shots of the COVID-19 vaccine received had no significant effect or change on the level of the liver and kidney function parameters.

From this study also, age of the test subjects had no significant effect on the liver function parameters, except for ALP level which was significantly decreased in the test subjects within the age range of 50-59 years compared with the age ranges of 20-29 years, 40-49 years, and 60-69 years. It has been reported that aging is associated with gradual alteration of hepatic structure and function [40], leading to elevated liver enzymes [41], which disagrees with the report obtained from this study, stating a non-significant difference in liver function parameters.

The study reported a non-significant effect of Covid-19 vaccine on renal and hepatic functions with regards to aging, except for ALP in which the mean for the test subject within 50 - 59 years is significantly reduced. Some studies have elucidated the relationship between aging and renal function, stating a decline in renal function with an increasing age [42]. Similarly, Bowker et al. [43] reported a significant increase in serum urea level in the elderly compared with the young individuals. However, report from this study revealed that age of the test subjects had no significant effect on the kidney function parameters among the various age groups when compared.

Furthermore, the sex of the test subjects had no significant effect on the liver and except for albumin level which was significantly higher in male subjects when compared with female subjects. Similarly, the sex (or gender) of the test subjects had no significant effect on the kidney function parameters for urea level which was significantly lower in male subjects when compared with female subjects. The significant differences noted for these parameters may be attributed to the variations in the physiology of male and female individuals.

4. CONCLUSION

From this study, it can be implied that the COVID-19 vaccine had no significant effect on the level of the liver function parameters except for ALT and albumin, which were significantly elevated, and total protein which was significantly decreased. Also, the COVID-19 vaccine had no

effect on the level of the kidney function parameters except for some electrolytes including sodium, potassium, and chloride ions, which were significantly elevated.

CONSENT

Both written and oral consents were obtained from the subjects.

ETHICAL APPROVAL

Ethical approval and clearance were obtained from the Ethical Committee of the Rivers State Ministry of Health and Rivers State University Teaching Hospital.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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