Journal of Advances in Medicine and Medical Research

34(17): 1-7, 2022; Article no.JAMMR.86820
ISSN: 2456-8899
(Past name: British Journal of Medicine and Medical Research, Past ISSN: 2231-0614, NLM ID: 101570965)

Therapeutic Effects of Vitamin E on Paraquat Induced Liver Toxicity in Male Albino Rats (*Rattus norvegicus*)

Okolonkwo, Benjamin Nnamdi [a*], Chukwubike, Udoka Okeke [b], Amadi, Chikadibia Fyneface [a] and Nyenke, Clement Ugochukwu [a]

[a] Department of Medical Laboratory Science, PAMO University of Medical Sciences, Port Harcourt, Rivers State, Nigeria.
[b] Department of Prosthetics and Orthotics, School of Health Technology, Federal University of Technology, Owerri, Imo State, Nigeria.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JAMMR/2022/v34i1731411

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/86820

Original Research Article

Received 04 March 2022
Accepted 09 May 2022
Published 23 May 2022

ABSTRACT

Paraquat is a high toxic organic chemical capable of causing organ and tissue damage by generation of free radicals. Vitamin E is a powerful antioxidant which is domiciled within the cells and organelles of the body and functions by acting as an initial responder against oxygen reactive species called free radicals which attack and destroy the tissues. The study was aim to assess a short term therapeutic effect of vitamin E on paraquat induced male albino rat. A total of 200 male albino rats were used for the study which were divided into four main groups (A, B, C, D) and each group had 50 rats. Each group was further subgrouped into two, having 25rats per subgroup. "A" group was without paraquat induction while "B", 'C" and "D" groups were induced in increasing dose of 0.02g, 0.04g and 0.06g respectively. "A" group had two subgroups; "Ao" and "Ave" which represented the sub-group not treated with Vit E and the subgroup treated with Vit E (500mg) respectively. This design also applied to group "B", "C" and "D" and paraquat induction frequency was fortnightly for three month followed by weekly treatment for one month. Blood and liver were collected and harvested respectively for liver function test (TB, CB, albumin, total protein and globulin) and histological assessment of the liver. There was a significant difference in liver

**Corresponding author: E-mail: bokolonkwo@pums.edu.ng;*

function markers among the “Ao”, “Bo”, “Co” and “Do”, p-value<0.05 except for globulin marker. There was a significant difference in liver function markers among the “Ave”, “Bve”, “Cve” and “Dve”, p-value<0.05 except for globulin marker. The result also showed that there were significant differences in intra-group comparison in total bilirubin and conjugated bilirubin markers, p-value<0.05 while other markers were not significantly different. This study observed that vitamin E has therapeutic effect on paraquat induced rats. Therefore, it can be used to reverse liver toxicity.

Keywords: Vitamin E; paraquat; rat; antioxidant; liver.

1. INTRODUCTION

Vitamin E is a fat soluble vitamin which belongs to a category of eight lipid-soluble compounds with antioxidant properties with the capability of shielding the cells and tissues from oxidative stress [1,2]. The eight groups are further divided into two groups comprising of tocopherols (a class of organic compounds having many vitamin E activity) and tocotrienols [2].The tocopherol group is made up of the alpha-, beta-, delta-, and gamma-tocopherols with each possessing a unique quality. Alpha (α)-tocopherol is the chemical form of vitamin E suitable for the nutritional need of the human body as well as the most active form of vitamin E [3]. Alpha (α) tocopherol plays several roles in the human body which ranges from the neutralization of free radicals which sponsors oxidative damages, to the protection of the cells against damages and the maintenance of the integrity of the cell membranes via preventing protein oxidation and fat peroxidation [3]. It also plays key roles such as gene control, participation in neurological performance, platelet aggregation inhibition, and vasodilation enhancement [3]. Vitamin can be sourced naturally from foods like seeds, nuts, some vegetables, and fortified products. It can also be sourced from dietary supplement [4].

Albino rats (*Rattus norvegicus*) mainly known as laboratory rat is a species of rat reared for scientific studies. They have played a key role in various fields of scientific studies such as seen in medical sciences, pharmacology, physiology, genetics and neuroscience [5].

Toxicant has been reported by many studies to be present in the environment due to increased industrial activities, human activities, poor waste management and agricultural chemical [6,7]. Paraquat is an organic compound also known as methyl viologen, a chemical herbicide or weed killer with highly toxic effect on ingestion or exposure [8,9,10]. According to Gotter (2022), paraquat is also known by the common name gramoxone, which is an extremely fatal poison on ingestion [9]. According to a report from National centre for biotechnology and information (2022), a concentrated solution of paraquat causes skin irritation among other damages such as nail shedding and cracking, and delayed wounds and cut healing [8]. According to Thomas (2018), exposure to paraquat can be confirmed through urinary dithionite test [10]. According to several studies carried out on the toxicity of paraquat, it was discovered that paraquat poisoning altered the levels of certain biochemical parameters [11,12]. Zhou et al. (2016) in their research highlighted the toxic impact of paraquat in both survivors and non-survivors where it led to significant alteration in the concentrations of some biochemical parameters [12].

Vitamin E is a powerful antioxidant which is domiciled within the cells and organelles of the body and functions by acting as an initial responder against oxygen reactive species (free radicals which attack and destroy the tissues [13]. Howard et al. (2011) revealed that vitamin E also promotes the repair of the plasma membrane [14]. Therefore, this study was focused on evaluating the ameliorative effect vitamin E administration will have on paraquat induced hepatotoxicity on male albino rats.

2. MATERIALS AND METHODS

2.1 Study Design

The study was a chronic experimental design of biological trial on 200 male albino rats with a mean weight of 0.2±0.02kg. The 200 rats were divided into four main groups of 50 rats each. The groups were A, B C and D. The “A” group was not induced with paraquat; “B” group was induced every two weeks with 0.02g of paraquat per kg of rat for three months; “C” group was induced every two weeks with 0.04g of paraquat per kg of rat for three months; “D” group was induced every two weeks with 0.06g per kg of paraquat for three months. Each of the main groups had subgroups. “A” group had “Ao” and

"Ave" subgroups; "B" group had "Bo" and "Bve" subgroups; "C" group had "Co" and "Cve" subgroups; "D" group had "Do" and "Dve" subgroups. "Ao", "Bo", "Co" and "Do" subgroups were not treated with vitamin E while "Ave", "Bve", "Cve" and "Dve" were treated orally with 500mg of vitamin E every week. However, treatment with Vit E commenced after the three months paraquat induction. After one month of weekly treatment with Vit E, the rats were sacrificed and their samples (blood and liver organ) were analyzed for liver function.

2.2 Animal Source

Two hundred rats of average weight of 0.2±0.02kg were obtained from Animal House, Department of Biology, Rivers State University of Science and Technology. The rats were transported to the study site and allowed to acclimatize for two week before proceeding with the study. The study was conducted in Department of Medical Laboratory Science, Rivers State University of Science and Technology.

2.3 Sample Collection Method

Blood sample was collected for liver function test and liver was harvested for histological analysis. Using syringe and needle, 2mls of blood was collected through cardiac puncture and dispensed in plain bottles. The blood was allowed to clot and spun at 4000rpm to obtain serum. By means of 70% chloroform anesthesia, animal sacrificed, liver organ harvested and preserved in 10% formal saline. The carcasses remaining were incinerated to avoid environmental pollution.

2.4 Laboratory Analysis

2.4.1 Bilirubin method

Bliribun was evaluated by method according to Young in 1997 [15]

Procedures:

Total Bilirubin: 1.5mls of reagent-1 (Sulphanilic acid, HCl and Dimethylsulphoxide) was added to two glass-tubes labeled 'Blank' and 'Test' respectively. 50*μL* of reagent-3 (Sodium nitrite) was added to the tube for test only and mixed; subsequently 100*μL* of sample was added to the 'Blank' and 'Test' tubes, mixed and incubated for exactly 5 minutes at room temperature. After which the absorbance were read spectrophotometrically at 530 – 580nm and 15 – 25^0C, with the instrument adjusted to zero with distilled water.

Calculation: Readings of (Sample – Sample blank) X 19.1 = Result in (mg/dL). Conversion factor: mg/dL X 17.1 = Result (*μL*/L).

Direct Bilirubin: 1.5mls of reagent-2 (Sulphanilic acid and HCl) was added to two glass-tubes labeled 'Blank' and 'Test' respectively. 50*μL* of reagent-3 (Sodium nitrite) was added to the tube for test only and mixed; subsequently 100*μL* of sample was added to the 'Blank' and 'Test' tubes, mixed and incubated for exactly 5 minutes at room temperature. After which the absorbance were read spectrophotometrically at 530 – 580nm and 15 – 25^0C, with the instrument adjusted to zero with distilled water.

Calculation: Readings of (Sample – Sample blank) X 14 = Result in (mg/dL). Conversion factor: mg/dL X 17.1 = Result (*μL*/L).

2.4.2 Total protein (Biuret colorimetric method)

Total protein was evaluated by method according to Burtis in 1999 [16]
Procedure

1mL of Biuret reagent was each added to three glass tubes labeled 'Blank', 'Standard' and 'Test', followed by 25*μL* each of Standard (7g/dL) and Sample added to the 'Standard' and 'Test' tubes respectively. The contents were mixed and incubated for 10 minutes at room temperature, after which, the absorbance (A) of the 'Test' and 'Standard' were read against the 'Blank'. The colour produced is stable for at least 30 minutes at room temperature.

Calculation: [A(Test) ÷ A(Standard)] X 7(Standard concentration)

= Result in g/dL

2.4.3 Albumin (Bromocresol green method) [17]

Albumin was evaluated by method according to Grant in 1987 [17]

Procedure: 3mls of Bromocresol green reagent was each added to three glass tubes labeled 'Blank', 'Standard' and 'Test', followed by 10*μL*

each of Water, Standard (7g/dL) and Sample added to the 'Blank', 'Standard' and 'Test' tubes respectively. The contents were mixed and incubated for 10 minutes at 20 – 25^{0}C, after which, the absorbance (A) of the 'Test' and 'Standard' were read against the 'Blank'. The colour produced is stable for at least 30 minutes at room temperature.

Calculation: [A (Test) ÷ A (Standard)] X 7 (Standard concentration)

= Result in g/dL

2.4.4 Globulin calculation method

Albumin was calculated by method according to Grant in 1987 [17]

In this method globulin value are calculated as a difference when albumin value are subtracted from the value of the total protein gotten from the same sample.

Globulin (g/dl) = Total protein (g/dl) – Albumin (unit in g/dl).

2.5 Statistical Analysis

The data generated from this study was analyzed using SPSS version 23.0 for descriptive and inferential statistics (ANOVA) for inter-group comparison and T-test for intra-group (sub-group) comparison at test significance, P-value<0.05.

3. RESULTS

Table 1, 2 and 3 show the comparative effects of vitamin E on the Chronic Toxicity of Paraquat in Albino Rats (*Rattus norvegicus*). Intergroup comparison of Ao, Bo, Co and Do was statistically significant, (*p*-value<0.05) in total bilirubin, conjugated bilirubin, total protein, and albumin but no significant (p>0.05) difference observed in the globulin among the group. Intergroup comparison of Ave, Be, Cve and Dve was statistically significant, (*p*-value<0.05) in total bilirubin, conjugated bilirubin, total protein, and albumin but no significant (p>0.05) difference observed in the globulin among the group.

4. DISCUSSION

In the quest to assess the therapeutic effect of Vitamin E on paraquat induced liver toxicity in male albino rats, different rat subgroups were studied based on paraquat induction dose. This was followed by inter- and intra- comparative analyses after treatment with vitamin E.

Table 1. Inter-group comparison of liver biomarkers in paraquat induced rat

Sub-group	T. Bilirubin (µmol/L)	D. Bilirubin (µmol/L)	T. Protein (g/dL)	Albumin (g/dL)	Globulin (g/dl)
A_0	0.81 ± 0.35	0.14 ± 0.03	7.52 ±0.25	3.90 ± 0.01	3.62 ± 0.03
B_0	3.53 ± 0.79[a]	1.10 ± 0.03[a]	6.05 ±0.38[a]	3.16 ± 0.01[a]	2.89 ± 0.03
C_0	9.29 ± 2.53[a]	1.08 ± 0.03[a]	6.26 ±0.57[a]	3.40 ± 0.03[a]	2.86 ± 0.03
D_0	13.56 ± 3.14[a]	1.57 ± 0.04[a]	6.54 ±0.51[a]	3.21 ± 0.04[a]	3.32 ± 0.02

Statistical significance: P ≤ 0.05

- *Index (a) = represents a statistically significant difference between the test subgroups and the control subgroups at each treatment month*

Table 2. Inter-group comparison of liver biomarkers in Vit E treated rats

Sub-group	T. Bilirubin (µmol/L)	D. Bilirubin (µmol/L)	T. Protein (g/dL)	Albumin (g/dL)	Globulin (g/dL)
A_{VE}	1.13 ± 0.24	0.28 ± 0.01	6.90 ±0.15	4.00 ± 0.02	2.91 ± 0.03
B_{VE}	2.45 ± 0.59[a]	0.45 ± 0.01[a]	6.73 ±0.26[a]	3.29 ± 0.01[a]	3.44 ± 0.02
C_{VE}	4.21 ± 0.78[a]	0.67 ± 0.04[a]	6.29 ±0.33[a]	2.99 ± 0.03[a]	3.30 ± 0.01
D_{VE}	6.93 ± 1.67[a]	1.05 ± 0.02[a]	6.31 ±0.35[a]	3.06 ± 0.02[a]	3.26 ± 0.02

Statistical significance: P ≤ 0.05

- *Index (a) = represents a statistically significant difference between the test subgroups and the control subgroups at each treatment month*

Table 3. Inter and intra groups comparison of liver markers after one month treatment

Sub-group	T. Bilirubin (µmol/L)	D. Bilirubin (µmol/L)	T. Protein (g/dL)	Albumin (g/dL)	Globulin (g/dL)
A_0	0.81 ± 0.35	0.14 ± 0.03	7.52 ±0.25	3.90 ± 0.01	3.62 ± 0.03
A_{VE}	1.13 ± 0.24	0.28 ± 0.01	6.90 ±0.15	4.00 ± 0.02	2.91 ± 0.03
B_0	3.53 ± 0.79[a]	1.10 ± 0.03[a]	6.05 ±0.38[a]	3.16 ± 0.01[a]	2.89 ± 0.03
B_{VE}	2.45 ± 0.59[a,b]	0.45 ± 0.01[a,b]	6.73 ±0.26[a]	3.29 ± 0.01[a]	3.44 ± 0.02
C_0	9.29 ± 2.53[a]	1.08 ± 0.03[a]	6.26 ±0.57[a]	3.40 ± 0.03[a]	2.86 ± 0.03
C_{VE}	4.21 ± 0.78[a,b]	0.67 ± 0.04[a,b]	6.29 ±0.33[a]	2.99 ± 0.03[a]	3.30 ± 0.01
D_0	13.56 ± 3.14[a]	1.57 ± 0.04[a]	6.54 ±0.51[a]	3.21 ± 0.04[a]	3.32 ± 0.02
D_{VE}	6.93 ± 1.67[a,b]	1.05 ± 0.02[a,b]	6.31 ±0.35[a]	3.06 ± 0.02[a]	3.26 ± 0.02

Statistical significance: $P \leq 0.05$

- *Index (a) = represents a statistically significant difference among intergroup comparison.*
- *Index (b) = represents a statistically significant difference observed within each group (intra-group i.e. Group B: B_0 Vs B_{VE})*

Comparison on the effect of dose-dependent toxicity among the various subgroups. Groups B_0, C_0, and D_0 were compared against the control group A_0 for the effect of paraquat on liver biomarkers; T. bilirubin, D. bilirubin, T. protein, albumin, and globulin. The result obtained showed there was a significant difference in the concentrations of T. bilirubin, D. bilirubin, T. protein, and albumin for all subgroups under consideration. However, there was no significant difference in globulin level. This could due to the fact that globulin proteins are not all produced in the liver. Albumin which is primarily produced in the liver was significantly affected after periods of paraquat induction. From the result obtained, it means that differences in paraquat dosage induction on rats have varying toxicity effect on the liver. This result is in agreement with the study by Rizvi in 2014 and Howard in 2011 [13,14].

The ability of vitamin E to repair the oxidative damage caused by paraquat on the cells and membranes of the liver was studied. The Vit E treated sub-groups (Ave, Be, Cve and Dve) were compared and the result revealed a significant difference in the liver parameters of the subgroups except for globulin. This means that vitamin E did not have any comparative effect on globulin levels in rats induced and rats not induced with paraquat. It may be due to the fact that paraquat also had no toxic effect on globulin concentration. This outcome also agrees with the studies conducted by (National Center for Biotechnology and Information (NCBI) in 2022, Rizvi in 2014, and Howard in 2011 [5,13,14].

Finally, an intra-comparison was done between the control groups A_0 and A_{VE} and the test subgroups B_0 and B_{VE}, C_0 and C_{VE}, D_0 and D_{VE} to determine the therapeutic potential of Vit E on increasing paraquat dosage. It was observed that there was a significant difference in the levels of T. bilirubin, and D. bilirubin of subgroups B_{VE}, C_{VE}, and D_{VE}. It means that Vit E had the potential to restore liver excretory function of bilirubin metabolism. Vit E was therapeutically effective in restoring liver function increasing toxicant exposure and liver damage, such that 0.06g of paraquat induced-hepatotoxicity was ameliorated by the vitamin especially for recovery of bilirubin metabolism. The recovery of bilirubin values was a sign that hepatocellular damage inflicted by the toxicant was recovering due to vitamin E treatment. The recovery of albumin and total protein levels after treatment was not achieved in one month of weekly treatment with Vit E even at the least toxicity level (0.02g). This corresponds with results of studies conducted by Rizvi in 2014, and Howard in 2011 [13,14].

5. CONCLUSION

This study has shown incomplete effectiveness of vitamin E in treating the paraquat-induced liver toxicity in albino rats within a month of weekly treatment. Although therapeutic success was achieved in the liver excretory function of bilirubin metabolism, a general therapeutic success may be possible in a long term treatment with Vit E.

CONSENT

It is not applicable.

ETHICAL APPROVAL

As per international standard or university standard written ethical approval has been collected and preserved by the author(s).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. York Morris, S. The Truth About Vitamin E Oil;2020.
   Available:https://www.healthline.com/health/food-nutrition/truth-about-vitamin-e-oil Retrieved;17/3/22.
2. Traber MG. and Bruno RS. Vitamin E". In BP Marriott, DF Birt, VA Stallings, AA Yates (eds.). Present Knowledge in Nutrition, Eleventh Edition. London, United Kingdom: Academic Press (Elsevier). 2020;115–36. ISBN 978-0-323-66162-1.
3. National Center for Biotechnology Information (2022). PubChem Compound Summary for CID 15939, Paraquat. Retrieved March 17, 2022
   Available:https://pubchem.ncbi.nlm.nih.gov/compound/VitaminE
4. Kubala, J.(2022). 8 Unique Benefits of Vitamin E.
   Available:https://www.healthline.com/health/all-about-vitamin-e#1.-May-reduce-markers-of-oxidative-stress-and-improve-antioxidant-defenses Retrieved 17/3/22
5. Kuramoto, T., Nakanishi, S., Ochiai, M., Nakagama, H., Voigt, B., Serikawa, T. Origins of Albino and Hooded Rats: Implications from Molecular Genetic Analysis across Modern Laboratory Rat Strains. PLoS ONE. 2012;7(8):e43059.
   Available:https://doi.org/10.1371/journal.pone.0043059
6. Onwuli, D., Ajuru, G., Holy, B. and Fyneface, C. A. The concentration of lead in periwinkle (Tympanotonos fuscatus) and river sediment in Eagle Island River, Port Harcourt, Rivers state, Nigeria. American Journal of Environmental Protection. 2014;2(2), 37-40
7. Fyneface, C. A., Emeji, R., Osere, H. and Nwisah, L. Concentrations of Nickel in Sediment and Periwinkle of Eagle Island River, Port Harcourt. Asian Journal of Fisheries and Aquatic Research. 2018;1(4):1-5.
8. National Center for Biotechnology Information (2022). PubChem Compound Summary for CID 15939, Paraquat. Retrieved March 17, 2022
9. Available:https://pubchem.ncbi.nlm.nih.gov/compound/Paraquat.
10. Gotter, A. (2022). What is paraquat?https://www.healthline.com/health/paraquat-poisoning#:~:text=Paraquat%20is%20a%20chemical%20herbicide,control%20weed%20and%20grass%20growth. Accessed 17/3/22
11. Thomas, S. H. L. Poisoning. Davidson's Principles and Practice of Medicine. 2018;7:131-150.
    ISBN-13: 978-0702070280;
    ISBN-10: 0702070289
12. Hashemi, R, Jaddi Y, Sadeghi M, Ghiamati, S. and Motazedi, M. Study of Toxicology Effects of Herbicide Paraquat on Heamatological Parameters of Mesopotamichthys sharpeyi. Open Journal of Marine Science. 2017;7:258-270.
    DOI: 10.4236/ojms.2017.72018.
13. Zhou, D. C., Zhang, H., Luo, Z. M., Zhu, X. Q., and Zhou, F. C. (2016). Prognostic value of hematological parameters in patients with paraquat poisoning. Sci Rep. 2016;6:36235.
    Available:https://doi.org/10.1038/srep36235
14. Rizvi, S., Raza, S. T., Ahmed, F., Ahmad, A., Abbas, S., Mahdi, F. The role of vitamin e in human health and some diseases. Sultan Qaboos Univ Med J. 2014;14(2):e157-65.
    Epub 2014 Apr 7.
    PMID: 24790736;
    PMCID: PMC3997530.
15. Howard, A. C., McNeil, A. K., McNeil, P. L. Promotion of plasma membrane repair by vitamin E. Nat Commun. 2011;20;2:597.
    DOI: 10.1038/ncomms1594.
    PMID: 22186893;
    PMCID: PMC3247818.
16. Young, D. S. Bilirubin estimation. Effects of preanalytical variables on Clinical Laboratory Tests. 2nd Edn. Washington. D. C. AACC Press;1997.
17. Burtis, A. and Ashwood, E. R. Eds Teitz: Textbook of Clinical Chemistry, 3rd edn. Philadelphia: W. B. Saunders. 1999;2184 – 2190.

18. Grant, G. H. and Kachmer, J. S. Amino Acids and Proteins; Fundamentals of Clinical Chemistry, Tietz N. W. Editor, 3rd Edn, WB Saunders Company, Philadel- phia. USA. 1987;328–329.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/86820