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Original Research Article

CLINICAL OUTCOMES AND PREDICTORS OF MORTALITY IN PARAQUAT POISONING: INSIGHTS FROM A TERTIARY CARE CENTER IN SOUTH INDIA

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ABSTRACT

Background: Paraquat poisoning remains a major public health issue in developing countries due to its high toxicity and easy availability. Despite its lethality, data on clinical course, treatment outcomes, and predictors of mortality are limited. The objective is to evaluate clinical features, outcomes, and predictors of mortality among patients admitted with paraquat poisoning at a tertiary care center in South India.

Materials and Methods: This cross-sectional study included 101 patients with confirmed paraquat poisoning. Data on demographics, clinical presentation, lab findings, treatments, and outcomes were analyzed using descriptive statistics and chi-square tests.

Results: The observed mortality rate was 78.2%, with all cases involving intentional ingestion. Most patients were male (94.6%). Deceased patients had a higher mean age (36.2 years) compared to survivors (29.6 years). Mortality was significantly associated with the amount ingested ($p = 0.0037$); patients who consumed <100 mL had better outcomes. AKI and ALI were strong predictors of death ($p = 0.001$ and 0.000). Hemodialysis was used in 36.63% of cases but showed no survival benefit. Empirical therapies (corticosteroids, cyclophosphamide, N-acetylcysteine) were widely used but did not improve survival. Time from ingestion to hospitalization was not significantly related to outcome.

Conclusion: This study confirms the high mortality linked to paraquat poisoning and identifies ingestion volume, AKI, and ALI as key predictors. Common treatments showed no significant benefit, highlighting the lack of effective therapy. These findings support the urgent need for a global paraquat ban and further research into better treatment strategies.

Keywords: Paraquat Poisoning, Acute Kidney Injury, Acute Liver Injury, Mortality, Public Health Issue.

INTRODUCTION

Paraquat is an organic salt with a molecular formula of 1,1'-dimethyl-4,4'-bipyridylium dichloride. Today, this herbicide is widely used in many countries and has extremely toxic and detrimental effects on multiple organ systems, including the renal, pulmonary, hepatobiliary, and gastrointestinal systems, if a person is exposed.[1] In the Indian subcontinent, where this study is conducted, self-intoxication by consumption of paraquat is a leading method of intake, and the most common cause of mortality is pulmonary complications, or multiple organ dysfunction syndrome, or MODS.[2]

This compound has no known antidote available, which makes it a life-threatening situation when ingested. The conventional treatment now involves the administration of a single dose of activated

charcoal or Fuller's earth.[3] As is the protocol in many poisoning cases, these substances work by binding to the paraquat in the stomach and preventing it from being absorbed into the bloodstream. By doing so, the amount of paraquat that reaches the vital organs of the body is reduced, potentially leading to a better outcome for the patient.

Paraquat gets metabolized by various enzymatic processes, including xanthine oxidase, NADPH-cytochrome reductase, nitric oxide synthase, and NADH-ubiquinone oxidoreductase.[4-8] This process results in the formation of free radicals like superoxide (O2.-), hydroxyl ions, and peroxynitrite (ONOO-) in the process and ultimately leads to tissue injury in the above-mentioned organ systems, with the lungs being the primary target due to the prominent presence of the polyamine transport system in the membrane alveolar cells type 1, 2, and Clara cells.[9]

Consumption of paraquat either through intentional or accidental exposure is associated with mortality rates as high as 83.3%, this is due to the development of MODS, ARDS, or Pulmonary Fibrosis.[10-12] These distinctly high mortality rates are primarily due to the lack of effective antidote or a curative treatment protocol. The main strand of the treatment right now is only symptomatic and it includes GI decontamination done within 2-4 hours of paraquat consumption, different combinations of immunosuppressive therapy like dexamethasone and cyclophosphamide, Antioxidants like N-acetyl cysteine (NAC), vitamin C and vitamin E, and Hemoperfusion, Hemodialysis.[3]

MATERIALS AND METHODS

Study Design: Cross-Sectional Analysis

Setting: Tertiary healthcare center in Kakinada, Andhra Pradesh, Kakinada.

Data Source: Medical records of patients admitted with paraquat poisoning during the study period.

Inclusion Criteria

- All patients with an alleged consumption of paraquat compounds.
- Confirmation can be based on:
  - History of paraquat ingestion
  - Clinical presentation suggestive of paraquat poisoning

Exclusion Criteria

- Patients with alleged consumption of compounds other than paraquat.

Data Collection: A standardized data collection form was developed to record relevant information from medical records.

Data Analysis

- Descriptive statistics are used to summarize patient demographics, clinical characteristics, treatment details, and outcomes.
- The frequency and distribution of variables were reported.
- For categorical variables, percentages were calculated.
- For continuous variables, measures of central tendency (mean) and dispersion (standard deviation) were reported.
- Appropriate statistical tests to test for significance were performed on SPSS software.

Ethical Approval and Guidelines Compliance: The study was approved by the Institutional Ethics Committee of Rangaraya Medical College, reference number IEC/RMC/2024/050/UG. All methods were performed in accordance with the relevant guidelines and regulations as per the Declaration of Helsinki and other applicable ethical standards.

RESULTS

The medical records of the patients were analyzed and the data was collected with a standardized form and a total of 101 cases have satisfied the eligibility criteria and further analyzed.

This study demonstrates a mortality rate of 78.2% with 79 of patients succumbing to death due to various complications and severe presentation and 22 patients (21.8%) surviving. It is also to be noted that all the cases included in this were intentional consumption.

The demographic features including age and gender were studied and distributive measures like mean were calculated. The calculated mean of age were further stratified based on mortality status and gender [Table 1]. The gender distribution in the study showed male predominance with 94.6% and females amounting for only 5.4% of the sample size.

Table 1: Distribution of Age among the Patients.

Status		Alive		Dead	
		Mean	Std.Deviation	Mean	Std.Deviation
Age	Gender				
	Male	29.4	10.2	36.5	13.4
	Female	30.7	11.0	28.7	6.0
Age (overall)		29.6	10.0	36.2	13.3

The amount ingested was classified into 2 groups, who consumed <100ml and who consumed >100 ml and a pearson chi square test was conducted to check for statistical significance. The results showed a statistical significance with a p–value of 0.033 indicating that people who consumed <100ml have a higher chance of survival when compared to people who consumed >100 ml of Paraquat. [Table 2].

Table 2: Comparing Amount Ingested with Mortality

Amount Ingested	No of Alive Patients	No of Dead Patients	P- Value
<100ml	21	59	0.033
>100ml	1	20	
Total	22	79	

Another variable that was considered was the Consumption to Hospitalization time, in which the cases were classified into 3 groups, ie <6 hours, 6-24 hours, >24 hours from alleged consumption till the medical contact. However, these groups did not show statistical significance when tested for correlation with the prognosis. The frequency of this variable is expressed in [Table 3].

Table 3: Comparing Consumption to Hospitalization Time with mortality.

Consumption to Hospitalization time	Frequency	Percentage	No of Alive Patients	No of Dead Patients
<6 hrs	66	65.3%	14	52
6-24 hrs	28	27.7%	6	22
>24 hrs	7	6.9%	2	5

Out of the 101 patients, Renal function tests (RFT's) were available only for 51 patients (50.49%), among them 43 patients (84.31% of cases with documented RFT's) had demonstrated Acute Kidney Injury (AKI). When the presence of AKI was tested for correlation with mortality, it showed statistical significance with a p-value of 0.01. This implies that the presence of AKI is associated with increased mortality. [Table 4] Out of these 43 patients with an AKI, 72.09% of them have undergone dialysis. When dialysis is considered, it was performed for 37 patients (36.63%) for a variable number of times [Table 5].

Additionally another manifestation that was studied was Acute Liver Injury (ALI), Liver function tests were documented only for 49 patients (48.51%), among them 39 patients had demonstrated Acute liver injury (79.59% of patients with documented LFTs). Chi square test yielded a significance with a p value of 0.000, thus inferring that the presence of ALI is associated with increased mortality. [Table 4]

Table 4: comparing Acute Kidney injury and Acute Liver Injury with Mortality.

Variable		No of Alive Patients	No of Dead Patients	P value
Acute Kidney Injury	Present	8	35	0.001
	Absent	6	2	
	Not documented	8	42	
	Total	22	79	
Acute Liver Injury	Present	7	32	0.000
	Absent	7	3	
	Not documented	8	44	
	Total	22	79	

Table 5: Comparing number of cycles of dialysis with mortality.

Number of cycles of Dialysis	Total No of patients	No of alive Patients	No of dead Patients
0	64	14	50
1	15	3	12
2	7	1	6
3	9	2	7
4	4	2	2
5	1	0	1
7	1	0	1

These patients were treated with empirical treatment based on clinical scenario and clinician's discretion. This consisted of variable combinations of corticosteroids like Methylprednisolone or Dexamethasone, Cyclophosphamide and N-Acetyl Cysteine. [Table 6]

Table 6: Frequency of the treatment administered with associated outcome

Treatment Given		Total	Percentage (%)	Number of alive patients	Number of Dead patients
Methyl Prednisolone	Not Given	39	38.6	10	29
	Given	62	61.4	12	50
N-Acetyl Cysteine	Not Given	12	11.9	4	7
	Given	89	88.1	18	71
Cyclo Phosphamide	Not Given	62	61.4	11	51
	Given	39	38.6	11	28
Dexamethasone	Not Given	60	59.4	15	45
	Given	41	40.6	7	34

DISCUSSION

Paraquat is an herbicide widely available in the developing world that is fatal even when consumed in minimal quantities. Our study showed a mortality of 78.2% that is consistent with a existing study (72.7%) by Ravichandran R et al (2020).[10] This study is one of the two studies from india that are similar to our study, them being the only two record based retrospective studies and the only other studies with sample size of greater than 50. Another study that have been mentioned earlier was conducted by Rao et al (2017) in Manipal, India, however this study demonstrates mortality rate of 61.4% which does not align with our study or study by Ravinchandran et al (2020).[10,11] This is might be owed to the fact that that study excluded the patients that have left against medical advice and might have skewed the data. The study by Rao et al (2017) is primarily based on comparing the mortality of the patients with role of hemoperfusion, our study cant offer any insight into this as Hemoperfusion was not available in our hospital and therefore not studied in our study.[11]

Another aspect of similarity between our study and the study by Ravinchandran et al (2017), is demonstrating statistical significance between the amount ingested and the mortality, our study showed a p value of 0.0037 when amount ingested was compared with the prognosis.[10] This infers that the patient who consumed less than 100ml of Paraquat have higher chance of survival than the patient who consumed more than 100ml.

In contrast, this study could not establish statistical significance between Acute kidney injury and mortality this might be due to factors like smaller sample size not powered enough to show significance.[10] But it is also to be noted that this study established significance between presence of lung injury and mortality, that was not analyzed in our study.[10]

Our study has displayed statistical significance for two common clinical manifestations of parquat consumption, they include Acute Kidney Injury and Acute Liver Injury, with p values of 0.0037 and 0.000 respectively. These indicate that the presence of either is associated with increased mortality. Studies by Ravinchandran et al (2020) and Rao et al (2017) have not studied the presence of Acute Liver Injury.

Another variable that was studied, Consumption to hospitalization time. The patients were divided into 3 groups and were tested for significance, however no significance was noted in this aspect. Another similar variable that is similar to this was the time to initiation of Hemoperfusion that was studied by Rao et al (2017),[11] that showed significance, inferring early initiation of hemoperfusion was associated with decreased mortality.

As far as our knowledge goes, Neither any Specific antidote has been named for paraquat poisoning till now nor any active clinical trials in human models are underway. Nevertheless one of the promising treatment that has shown efficacy in rat models by reducing PQ concentrations, decreasing damage caused by oxidative stress and also increasing expression of Nrf-2 at a genetic level, is Anthrahydroquinone-2-6-disulfonate.[13] One other technique that can be discussed is Sequential whole gastric and bowel irrigation based on a study that was performed in China.[14] This technique involves administering 60 g of montmorillonite powder for oral administration, followed by small-volume low-pressure manual gastric lavage with 2.5% bicarbonate. Then 30 g of activated charcoal, 30 g of montmorillonite powder, and polyethylene glycol electrolyte lavage solution were given one after another for gastrointestinal lavage once a day for five days. This study shows that there is significant reduction in incidence of hypokalemia, Hypoxia (Pao2 <60 mmhg), shorter average laxative time, lower mortality, and longer survival time of dead cases in comparison with conventional treatment group.[14] However it is also to noted that the sample size is of 94 patients only and actual applicability of this technique is yet to be verified by studies with larger scales.

In contrast, no study has performed in-depth analysis of empirical treatment that is widely used due to absence of a detailed protocol in case of Paraquat Poisoning. Our study has tried to find a significant correlation between usage of Corticosteroids like Methylprednisolone and Dexamethasone, an immunomodulator like cyclophosphamide and antioxidant therapy with N-Acetyl Cysteine. But it was unsuccessful in finding significance which might be owed to smaller sample size than required, the frequency of administration of these drugs were described in [Table 6]. Additionally, the role of Hemodialysis in reduction of mortality associated with PQ poisoning was studied by various studies over the period of time and a meta analysis conducted on the same, yielded results stating that there was no significant reduction of mortality with treating the patients with hemodialysis.[15] This correlates with our study which also did not find any significance between Dialysis and mortality.

Another aspect we aim to highlight with our paper is the need for an international intervention by imposing a complete ban on this toxic compound, The ban on paraquat is a not new entity, as it has been previously banned by more than 60 countries including United Kingdom, China, Germany, South Korea, and Switzerland.[16] This has been validated and demonstrated by many instances, like a study that was conducted in Taiwan,[17] in which there was a reduction in Paraquat associated suicides by 58% and a reduction in total pesticidal suicides by 37%.[17] Comparable patterns in reduction of pesticide associated suicides were also noted in South Korea and Sri Lanka by 46% and 50% respectively.[18,19] This could also raise concerns

about decreased agricultural production due to the ban on highly effective pesticides. However, several studies conducted in countries such as South Korea, Vietnam, and India have addressed this issue, demonstrating that the absence of paraquat as a herbicide does not lead to a reduction in agricultural yield.[19]

Limitations:

- The accuracy of the data is dependent on the quality of medical record documentation.
- Recall bias of the patients and patient's attendees in history-taking may lead to inaccurate assumption of the amount ingested.
- This study does not take the long-term complications of the patients and considers the patient alive when discharged.
- This study is not powered enough to show statistical significance between treatments administered and survival.
- Due to limited availability of laboratory data, the patients with absent Renal function tests and liver function tests were considered as Not-Documented in the statistical tests.

CONCLUSION

Paraquat poisoning is a severe public health issue in developing countries due to its high fatality rate and widespread availability. Our study, consistent with existing research, highlights a significant association between ingestion quantity and mortality but found no statistical significance for commonly used empirical treatments such as corticosteroids, immunomodulators, antioxidants, or hemodialysis. Promising experimental treatments like Anthrahydroquinone-2-6-disulfonate and sequential gastrointestinal irrigation require further validation in larger trials.

We also emphasize the need for global ban on paraquat, supported by evidence from countries like Taiwan, South Korea, and Sri Lanka, where such bans have significantly reduced pesticide-associated suicides without impacting agricultural yields. As over 60 nations have already implemented bans, global action is critical. Future research should focus on refining treatment protocols, validating novel therapies, and promoting regulatory measures to mitigate the devastating consequences of paraquat poisoning.

REFERENCES

1. Sukumar CA, Shanbhag V, Shastry AB. Paraquat: The poison potion. Indian J Crit Care Med. 2019;23(Suppl 4):S262-S264. doi:10.5005/jp-journals-10071-23306. PMID: 32021001; PMCID: PMC6996657.
2. Kanchan T, Bakkannavar SM, Acharya PR. Paraquat poisoning: Analysis of an uncommon cause of fatal poisoning from Manipal, South India. Toxicol Int. 2015;22(1):30-34.
3. Gawarammana IB, Buckley NA. Medical management of paraquat ingestion. Br J Clin Pharmacol. 2011;72(5):745-757. doi:10.1111/j.1365-2125.2011.04026.x. PMID: 21615775; PMCID: PMC3243009.
4. Kelner MJ, Bagnell R. Paraquat resistance associated with reduced NADPH reductase in an energy-dependent paraquat-accumulating cell line. Arch Biochem Biophys. 1989;274(2):366-374. doi:10.1016/0003-9861(89)90450-5. PMID: 2802616.
5. Peng J, Stevenson FF, Oo ML, Andersen JK. Iron-enhanced paraquat-mediated dopaminergic cell death due to increased oxidative stress as a consequence of microglial activation. Free Radic Biol Med. 2009;46(3):312-320.
6. Bus JS, Gibson JE. Paraquat: Model for oxidant-initiated toxicity. Environ Health Perspect. 1984;55:37-46. doi:10.1289/ehp.845537. PMID: 6329674; PMCID: PMC1568364.
7. Clejan L, Cederbaum AI. Synergistic interactions between NADPH-cytochrome P-450 reductase, paraquat, and iron in the generation of active oxygen radicals. Biochem Pharmacol. 1989;38(11):1779-1786. doi:10.1016/0006-2952(89)90412-7. PMID: 2500125.
8. Ahmad I, Kumar A, Shukla S, Pandey H, Singh C. The involvement of nitric oxide in maneb- and paraquat-induced oxidative stress in rat polymorphonuclear leukocytes. Free Radic Res. 2008;42(10):849-862. doi:10.1080/10715760802513733. PMID: 18985485.
9. Rannels DE, Kameji R, Pegg AE, Rannels SR. Spermidine uptake by type II pneumocytes: Interactions of amine uptake pathways. Am J Physiol. 1989;257(6 Pt 1):L346-L353. doi:10.1152/ajplung.1989.257.6.L346. PMID: 2610.
10. Ravichandran R, Amalnath D, Shaha KK, Srinivas BH. Paraquat poisoning: A retrospective study of 55 patients from a tertiary care center in Southern India. Indian J Crit Care Med. 2020;24(3):155-159. doi:10.5005/jp-journals-10071-23369. PMID: 32435092; PMCID: PMC7225766.
11. Rao R, Bhat R, Pathadka S, Chenji SK, Dsouza S. Golden hours in severe paraquat poisoning: The role of early haemoperfusion therapy. J Clin Diagn Res. 2017;11(2):OC06-OC08. doi:10.7860/JCDR/2017/24764.9166. PMID: 28384906; PMCID: PMC5376772.
12. Prasad DRMM, Chennabasappa A. Outcome of paraquat poisoned patients treated with a commonly used therapeutic flowchart: A case series. Asia Pac J Med Toxicol. 2015;4(4):139-142. doi:10.22038/apjmt.2015.6359.
13. Qian J, Wu CY, Wu DM, et al. Anthrahydroquinone-2-6-disulfonate is a novel, powerful antidote for paraquat poisoning. Sci Rep. 2021;11:20159. doi:10.1038/s41598-021-99591-4.
14. Zhao B, Dai J, Li J, et al. Clinical study on the treatment of acute paraquat poisoning with sequential whole gastric and bowel irrigation. Zhonghua Lao Dong Wei Sheng Zhi Ye Bing Za Zhi. 2015;33(3):213-215. PMID: 25916451. [Chinese]
15. Eizadi-Mood N, Jaberi D, Barouti Z, et al. The efficacy of hemodialysis on paraquat poisoning mortality: A systematic review and meta-analysis. J Res Med Sci. 2022;27:74. doi:10.4103/jrms.jrms_235_21. PMID: 36353345; PMCID: PMC9639714.
16. Davies E. What countries have banned paraquat? Drug Watcher. November 29, 2022. Accessed September 1, 2024. https://www.drugwatcher.org/what-countries-banned-paraquat/.
17. Chang SS, Lin CY, Lee MB, et al. The early impact of paraquat ban on suicide in Taiwan. Clin Toxicol (Phila). 2022;60(1):131-135. doi:10.1080/15563650.2021.1937642.
18. Kim JW, Kim DS. Paraquat: Toxicology and impacts of its ban on human health and agriculture. Weed Sci. 2020;68(3):208-213. doi:10.1017/wsc.2020.11.
19. Pesticide Action Network UK. The Paraquat Problem. 2017. Accessed September 1, 2024. https://www.pan-uk.org/paraquat/.