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ASSOCIATION OF URINE SODIUM DITHIONITE TEST WITH CLINICAL PROFILE AND BIOMARKERS IN PATIENTS WITH PARAQUAT POISONING

Clinical Research

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ABSTRACT

Background: Paraquat is a commonly used herbicide in agriculture. Our study aimed to diagnose Paraquat poisoning cases by urine sodium Dithionite test and correlate the clinical and biochemical profile with varying grades of positivity. **Methodology** This cross-sectional study was conducted in 50 patients from Tirunelveli Medical College Hospital, Tamil Nadu. Socio-demographic details, comorbid illnesses, and quantity of poison ingested, time duration of poison intake to hospitalization are obtained using a structured proforma. Paraquat poisoning was confirmed with Urine Sodium Dithionite test. Biochemical investigations were done on the day of admission, day 3, and day 5 after admission. **Results:** Statistical analysis is done with SPSS 26.00. 37 males and 13 females were included in this study. 20% of patients had mild positive, 32% had moderate positive and 48% had strong positive results in the Sodium dithionite test. 62% had oral ulcers, 42% had abdominal pain, 50% had lung injury, 38% had acute liver Injury, and 34% had acute kidney injury. 42% of patients died within 48 hours of admission due to diffuse alveolitis and cardiotoxicity. 36% of patients died between 3 and 7 days after admission. 14% had died after 7 days and 8% of patients survived after 28 days of poisoning. Age positively correlates with Day 3 creatinine and Day 3- direct bilirubin. Day 3 urea significantly correlates with creatinine, total bilirubin, and day 3 AST and ALT. Day 5 urea shows positive significance with total and direct bilirubin ($P < 0.05$), AST, and ALT. There is no significant association between the amount of poison consumed and the duration of stay in the hospital or the development of complications. **Conclusion:** This study shows urine sodium dithionite test plays an important role in diagnosing paraquat poisoning. Early diagnosis and prompt treatment decrease morbidity.

KEYWORDS

Paraquat poisoning, Urine Sodium Dithionite, ARDS

INTRODUCTION

Paraquat is a rapidly-acting, nonselective herbicide that is relatively inexpensive and these characteristics contribute to its widespread use in agriculture fields in developing countries like India. In India, it is available as a dichloride salt under the trade names Gramoxone and Weedol. Cases of paraquat poisoning have been reported from all over the world. Paraquat is classified under class II chemical which is moderately hazardous by the World Health Organization. [1, 2]. The active ingredient is 1, 1'- dimethyl 4,4'- bipyridinium which is toxic to humans.[3]

Paraquat ingestion is a lethal poison in many parts of Asia, Pacific nations, and the Americas [4]. Dermal or spray exposure generally causes localized injury. Paraquat ingestion of less than 20–30 mg/kg produces no symptoms or only mild GIT symptoms. Patients who ingest 20–40 mg/kg are most likely to die from pulmonary fibrosis, which progresses after a few days to a few weeks. Patients who ingest greater than 40 mg/kg (>15 ml of a 20% solution for a 70 kg patient) usually die within hours to a few days. [5]. However, accidental ingestion has an extremely high case-fatality rate [6]. Largely for this reason, paraquat has been restricted in many parts of the world. Paraquat poisoning is a grave public health problem in the state of Tamil Nadu in India. [7]

Paraquat is most commonly consumed with suicidal intentions. The possible routes of exposure include contact through the skin and eyes, ingestion, and inhalation. Ingestion, especially in a concentrated form, results in extensive damage to the gastrointestinal mucosa due to the corrosive nature of the compound. Paraquat intoxication causes damage to multiple organs such as the lungs, liver, and kidney. The major effects of acute poisoning include abdominal pain, vomiting, diarrhea, pulmonary fibrosis, cardiac, renal, and hepatic failure.

Paraquat consumption of >40 mg/kg results in multiple organ dysfunction with death within 48 hours of consumption and intake of < 20 mg/kg will result in mild symptoms and the possibility of survival [4]. Paraquat poisoning is associated with very high mortality rates due to the high toxicity of the compound and the lack of availability of effective early diagnostic methods and standard operating protocols for earlier management. So, there is a need for developing a diagnostic procedure and standardization of treatment to avoid early mortality and morbidity among the family members of farmers who are the backbone of many developing countries like India. Hence our study aimed to standardize the urine sodium dithionite test which is a point-of-care test, to analyze the clinical profile, biochemical tests, morbidity, and mortality patterns in paraquat poisoning.

METHODOLOGY

This cross-sectional study was conducted in the toxicology unit of Tirunelveli Medical College Hospital, in Tamil Nadu, South India. The study was conducted from September 2022 to May 2023. Totally 50 patients with paraquat ingestion were included in this study. During admission, Socio-demographic details of the patients like age, gender, comorbid illnesses, and quantity of poison ingested, time duration of poison intake to hospitalization are obtained using a structured proforma. Clinical Presentation at the time of admission was recorded, and the specific treatment for paraquat poisoning was initiated immediately confirming with Urine Sodium Dithionite after standardizing the test procedures. Biochemical investigations were done on the day of admission, day 3, and day 5 after admission to correlate the clinical conditions and management of the poisoning with an ERBA 360 automated fully analyser.

Urine Sodium Dithionite – Paraquat poisoning

Reagent preparation

1% sodium dithionite Mix 1 g of sodium dithionite in 100ml of distilled water

A. 1 *N* sodium hydroxide: Mix 4g of Sodium hydroxide in 100 ml of water
B. Take 2ml from reagent A and 2 ml from reagent B and mix well for the test procedure

Test procedure

2 ml of freshly prepared 1% sodium dithionite in 1 *N* sodium hydroxide were added to 10 mL of urine sample, and mixed well The development of a dark blue, blue, green or mild yellow color observed.

If the urine sample turns black, it indicates the presence of a very high concentration of paraquat and the test should be repeated after diluting the urine sample.

The test is based on the reduction of the paraquat cation to a blue radical ion by sodium dithionite in an alkaline medium. To 10 mL of urine sample, 2 ml of freshly prepared 1% sodium dithionite in 1 *N* sodium hydroxide is added and mixed well. The development of blue or green color indicates the presence of paraquat in the urine sample [Figure 1]. If the urine sample turns black, it indicates the presence of a very high concentration of paraquat and the test should be repeated after diluting the urine sample. The sodium dithionite test can detect paraquat up to a concentration of 1µg/mL in a clear urine sample. The test can also be performed as a quantitative test by using known concentrations of paraquat solutions and comparing the color change in the urine sample. [5]

Sensitivity of urine Sodium dithionite test

The sodium dithionite test can detect paraquat up to a concentration of 1µg/mL in a clear urine sample. The test can also be performed as a quantitative test by using known concentrations of paraquat solutions and comparing the color change in the urine sample (figure 1).

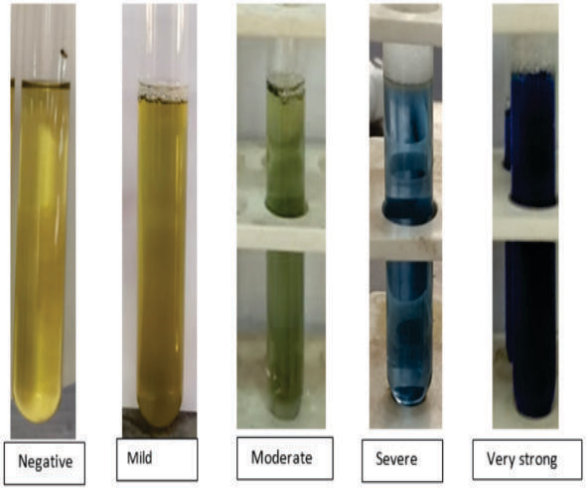

Figure 1: Urine sodium dithionite test (semi quantitative) shows various concentration of paraquat in urine sample

Mild: Indicate presence of 3 µg/ml of paraquat in urine Sample
Moderate: Indicate presence of 10 µg/ml of paraquat in urine Sample
Strong: Indicate presence of 100 µg/ml of paraquat in urine Sample
Very strong: Indicate presence of 100 µg/ml of paraquat in urine Sample

Results and statistics

Statistical analysis is done with SPSS 26.00. 37 males and 13 females were included in our study (table 1). Figure 2 shows the distribution of paraquat ingestion among various Age groups and Sex. According to the figure, the age group from 20 to 40 had more paraquat consumption than others.

As per Table 2 only 26% cases arrived at the hospital within the golden hours that is, within 4 hours. 52% cases arrived between 4 to 12 hours.

20% of patients had mild positive, 32% had moderate positive and 48% had strong positive in the Sodium dithionite test (Table 3). 62% had oral ulcers, 42% had abdominal pain, 50% had lung injury, 38% had acute liver Injury, and 34% had acute kidney injury. 42% of patients died within 48 hours of admission due to diffuse alveolitis and cardiotoxicity (Table 4).

According to figure 3, isolated Kidney involvement was less and multi-organ involvement was more among the patients who consumed paraquat 36% of patients died between 3 and 7 days after admission. 14% died after 7 days and 8% of patients survived after 28 days of poisoning (Table 5).

As per Table 6, the Mean and SD of Age were 31.40 ± 13.590, the Mean and SD of urea on Day 3 were 45.94 ±36.898, the Mean and SD of urea on day 5, was 68.86 ± 91.140, the Mean and SD of creatinine at day 3 1.718± 1.1155, the mean and SD of creatinine at day 5 was 2.306 ±3.3358, the mean and SD of total bilirubin at day 3 and day 5 was 1.3734 ± 1.507 and 1.882 ±3.225, the mean and SD of AST at day 3 and day 5 was 48.54 ± 46.964 and 38.54± 49.848, the mean and SD of ALT at day 3 and day 5 was 50.4 ± 59.661 and 60.23± 56.234.

As per table 7, Sex, urea, creatinine, total bilirubin, direct bilirubin AST, and ALT are positively correlated with paraquat poisoning on Day 5(P≤0.001); on Day 3 urea was not significantly changed. Total bilirubin (P≤0.000) and direct bilirubin ((P≤ 0.001) shows significant changes at day 3((P≤ 0.04). The amount of ingestion and day since consumption show a significant correlation with radiological findings and complications including organ dysfunction (P≤0.001).

Table 1: Age and sex distribution in Paraquat poisoning

Age in years	Males	Females	Total (percent)
18-29	17	10	27 (54)
30-39	8	3	11 (22)
40-49	4	3	7 (14)
>50	3	2	5 (10)
TOTAL	37	13	50

Table 2: Distribution of patients according to time since consumption to arrival in hospital

Time since consumption to arrival in hospital	No.of patients	Percent
<4 hours	11	22
4-12 hours	26	52
>12 hours	13	26

Table 2, shows the distribution of Time of admission after ingestion of paraquat poisoning. 22% of patients were admitted within 4 hours, 52% were brought to the hospital between 4-12 hours after ingestion, and 26% were brought to the hospital after 12 hours of ingestion.

Table 3: Distribution of Paraquat poisoning according to the strength of positivity of Urine Sodium dithionite test (USD)

USD result	No. of patients	Percentage
Mild positive	10	20
Moderate positive	16	32
Strong positive	10	20
Very Strong	14	28

Table 4: Distribution of clinical features and organ dysfunction in patients with Paraquat poisoning

Clinical feature	No. of patients	Percentage
Oral ulcers	31	62
Abdomen pain	21	42
Dyspnoea/lung injury	25	50
Acute liver injury	19	38
Acute kidney injury	17	34

Table 5: Mortality pattern in patients with Paraquat poisoning

Outcome of poisoning	No. of patients	Percent
Acute mortality <48 hours	21	42
Early mortality 3-7 days	18	36
Late mortality 7- 28 days	7	14
Survival >28 days	4	8

Table 6: Mean and SD of various biochemical parameters at day 3 and day 5 of admission of patient with paraquat ingestion and Changes of Various Biochemical Parameters after Paraquat ingestion on day 3 and day 5 of admission

Analytes	Day after admission	Mean	Std. Deviation	Std. Error Mean
Age		31.40	13.590	1.922
Urea	Day 3	45.94	36.898	5.218
	Day5	68.86	91.140	12.889
Creatinine	Day 3	1.718	1.1155	.1578
	Day5	2.306	3.3358	.4718
T.B	Day 3	1.3734	1.50771	.21322
	Day5	1.8826	3.22556	.45616
D.B	Day 3	0.6204	.59572	.08425
	Day5	1.1002	1.94774	.27545
AST	Day 3	48.54	46.964	6.642
	Day5	38.54	49.848	7.050
ALT	Day 3	50.40	59.661	8.437
	Day 5	60.23	56.234	9.532

Table 7: Chi-Square test correlation of various biochemical parameters, complications, and duration of hospital stay of the patient with paraquat poisoning

	Age	sex	Dyspnoea	Throat pain	Urea day 3	Urea day 5	Creatinine 3	Creatinine 5	T.B day 3	T.B day 5	D.B day 3	D.B day5	AST Day 3	AST day 5	ALT day 3	ALT day 5	Radiological findings	Complications (Organ dysfunction	Duration of stay
Chi-Square	20.76	11.520	2.000	0.080	13.36	286.96	21.76	261.52	37.00	260.6	59.44	234.80	20.0	220.7	14.80	312.88	28.88	21.60	49.840
df	28	1	1	1	35	23	22	21	24	21	18	19	34	23	35	20	1	4	11
Asymp. Sig.	0.835	0.001	0.157	0.777	1.000	0.000	0.474	0.000	0.044	0.000	0.000	0.000	0.97	0.000	0.999	0.000	0.000	0.000	0.000

As per the chi-square test sex, urea, creatinine, total bilirubin, direct bilirubin AST, and ALT are positively correlated with paraquat poisoning on Day 5(P≤0.001); at Day 3 urea was not significantly changed. Total bilirubin (P≤0.000) and direct bilirubin ((P≤ 0.001) shows significant changes at day 3((P≤ 0.04). The amount of ingestion and day since consumption show a significant correlation with radiological findings and complications including organ dysfunction (P≤0.001).

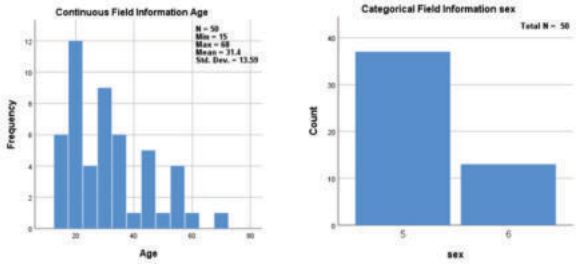

Figure 2: Shows distribution of paraquat ingestion among various Age groups and Sex As per figure 2 the age group from 20 to 40 had more paraquat consumption than others and males had consumed more than the female population

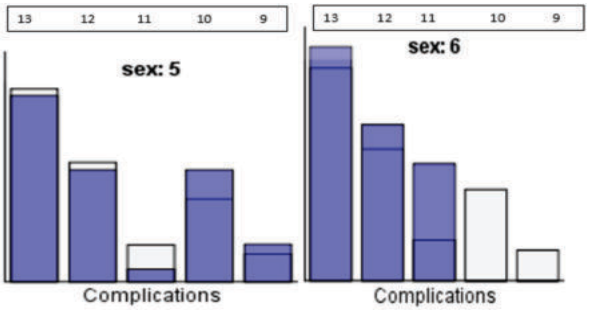

Figure 3: As per the above figure, Isolated Kidney involvement was less and multi-organ involvement was more among the patients who consumed paraquat 9. Acute Kidney Injury, 10. Multi Organ Dysfunction, 11. Acute respiratory distress syndrome 12. Cardiac Involvement, 13. Liver Failure

DISCUSSION

Paraquat poisoning is very prevalent among younger age groups in developing countries like India and it has a high Mortality rate of 92 %. The strength of positivity of the urine sodium dithionite test is directly proportional to the amount of poison consumed. Paraquat is most commonly consumed with suicidal intentions. The possible routes of exposure include contact through the skin and eyes, ingestion, and inhalation. Ingestion, especially in a concentrated form, results in extensive damage to the gastrointestinal mucosa due to the corrosive nature of the compound. Paraquat intoxication causes damage to multiple organs such as the lungs, liver, and kidney. The major effects of acute poisoning include abdominal pain, vomiting, and diarrhea, and pulmonary fibrosis, cardiac, renal, and hepatic failure.

It was a valuable tool in identifying the poison in 5 patients who were brought to the Emergency Room with a history of unknown poisoning. Therefore, urine SDT should be performed as a Point of Care Test (POCT) in all cases of unknown poisoning to initiate early management.

Paraquat interferes with the mitochondrial respiratory chain by its oxidation-reduction reaction and leads to the formation of oxygen free radicals. The free radicals cause lipid peroxidation and damage the endothelial cells of alveolar capillaries and pneumocytes. Supplemental oxygen is not recommended for the treatment of paraquat poisoning. The oxygen-free radical-mediated cytotoxic injury results in the worsening of pulmonary alveolar infiltrates ending up in ARDS and Pulmonary fibrosis. All cases were treated with intravenous methylprednisolone for the first 3 days and intravenous cyclophosphamide 15 mg/kg on day 2 and day 3 [8, 9].

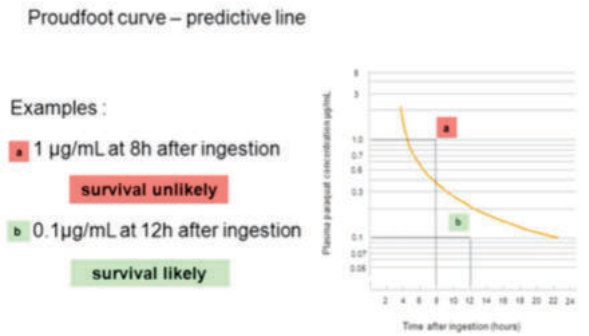

Figure 4: Shows the Association between quantity and time of presentation after ingestion of paraquat poisoning and morbidity and mortality

Age, sex, and mortality pattern were similar to other studies from South India [10, 11]. The mean age of the patients in our study was 31.40±13.59 similar to previous studies from India.

The mean amount of poison consumed was 46.5 ml and the overall mortality was 92 % in our study. Oral ulcers, abdominal pain, dysphagia, and dyspnoea are the common symptoms which were similar to previous studies [12, 13]. Figure 4 shows increased mortality when the time of presentation to hospital after paraquat ingestion is prolonged. In our study only 22% patients arrived within the golden hours of less than 4 hours.

50 % of patients developed respiratory failure and succumbed due to the development of acute respiratory distress syndrome. Diffuse alveolitis occurs over 1 to 3 days followed by pulmonary fibrosis. ARDS develops after 24 – 48 hours. The concentration of Paraquat is 10 to 20 times greater in the lungs than in the plasma. The higher concentration in the lungs is due to the energy-dependent uptake of paraquat by the alveoli. This gradient persists even after the paraquat levels decrease in the blood. [14, 15, 16]. 19 out of 29 patients who survived beyond 48 hours developed (65%) acute liver injury. According to Yang CJ et al, toxic hepatitis developed 6.7±6.3 days of exposure to paraquat. Patients with hepatitis suffered from acute respiratory and renal failure than those patients without hepatitis. Peak values of AST and ALT were observed on 9.5±8.8 days. [17]

A study by Gheslaghi et al revealed that AST and ALT rapidly elevated and peaked at day 3. They concluded liver injury was not associated with an increased risk of mortality [18]. The rise in ALT was specific in predicting mortality according to Fengjun et al 19. The liver plays a vital role in enzyme metabolism and detoxification as the liver is the main source of intrinsic anti-oxidants. Studies have shown that paraquat poisoning results in acute liver injury. As the liver is more vulnerable to reactive oxygen species, the injury manifests as persistent elevation of aminotransferases. [20, 21]

The study by Sandhu et al showed 76.5 % of cases with paraquat poisoning developed acute renal failure [12]. Development of toxic

hepatitis, renal dysfunction, and metabolic acidosis had a significant odds ratio according to a study by Hong Y et al.[22].Rao et al studied that, early haemoperfusion (≤ 6 hours) had better survival rates compared to those who received late haemoperfusion (>6 hours) [23].

Cavalli RD et al reported that the survival rate in patients without active treatment was only 13% even with non-fatal dose ingestion of paraquat and it increased to more than 50% with active treatment modality like hemoperfusion, in patients with fatal dose consumption [24]. Combined therapy with hemoperfusion and Continuous venous hemofiltration (CVVH) increased the survival. Several studies proved that early hemoperfusion improved the survival outcomes in paraquat-poisoned patients [25]. In all cases of significant paraquat poisoning hemoperfusion should be started within 4 hours of ingestion.

CONCLUSION

Paraquat is commonly used herbicide and highly lethal, its ingestion either accidental or suicidal causes more morbidity and mortality among agricultural population in Pacific nations, and the Americas. Paraquat is a rapidly-acting, nonselective herbicide that is relatively inexpensive and easily available. Our study concludes that urine sodium dithionite test can be done at the bedside test and plays an important role in the early diagnosis and initiation of early intervention of treatments and helps to prevent mortality and morbidity and social stigma. And our study shows prognostic significance with various organ involvement after paraquat ingestion with LFT and RFT, our study concludes that Serum urea and creatinine positively correlated with renal involvement, and LFT plays an independent role in the Prognosis of Paraquat poisoning

Our study will help to create awareness about concentration determination for the preparation of herbicide to avoid its toxicity and help to prepare guidelines for Primary prevention, especially government laws, public awareness, and education of health professionals regarding the seriousness of this problem are the keys to getting rid of this lethal poisoning in India

REFERENCES

1 The WHO Recommended Classification of Pesticides by Hazard and guidelines to Classification, 2019 edition [Internet]. World Health Organization, Geneva.2020.[Cited 2022 Jul 12].Available from: https:// www.who.int/publications/i/item/9789240005662

2 Paraquat Monograph - Pesticide Action Network Asia Pacific [Internet]. [Cited 2022 Aug.17].Available from: https://panap.net/resource/ paraquat-monograph

3 Dinis-Oliveira RJ, Duarte JA, Sánchez-Na Varro A, Remião F, Bastos ML, Carvalho. Paraquat Poisonings: Mechanisms of Lung Toxicity, Clinical Features, and Treatment. Crit Rev Toxicol.2008; 38(1):13-71.

4 Gunnell D, Eddleston M, Phillips MR, Konradsen F. The global distribution of fatal pesticide self-poisoning: a systematic review. BMC Public Health 2007; 7:357.

5 Lock EA, Wilks MF. Paraquat. In: Handbook of Pesticide Toxicology, 3rd ed, Krieger RI (Ed), Academic Press, San Diego 2010.

6 Senarathna L, Eddleston M, Wilks MF, et al. Prediction of outcome after paraquat poisoning by measurement of the plasma paraquat concentration. QJM 2009; 102:251.

7 Jones GM, Vale JA. Mechanisms of toxicity, clinical features, and management of diquat poisoning: a review. J Toxicol Clin Toxicol 2000; 38:123.

8 Koo JR, Yoon JW, Han SJ, Choi MJ, Park II, Lee YK, et al. Rapid analysis of plasma paraquat using sodium dithionite as a predictor of outcome in acute paraquat poisoning. Am J Med Sci 2009; 338(5):373–377. DOI: 10.1097/MAJ.0b013e3181b4deee.

9 Naik N, Desai A et al. Clinical profile and Outcome of paraquat poisoning at a tertiary care center in North Karnataka, a retrospective observational study. Medica Innovatica.2022;11: 97-100

10 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.

11 Cherukuri H, Pramoda K, Rohini D, Thunga G, Vijaynarayana K, Sreedharan N, Varma M, Pandit V. Demographics, clinical characteristics and management of herbicide poisoning in tertiary care hospital. Toxicol Int. 2014 May; 21(2):209-13. doi: 10.4103/0971-6580.139813. PMID: 25253933; PMCID: PMC4170565.

12 Sandhu JS, Dhiman A, Mahajan R, Sandhu P. Outcome of paraquat poisoning. A five-year study. Indian J Nephrol.2003; 13:64-8.

13 Vale J, Meredith T, Buckley B. Paraquat poisoning: clinical features and immediate general management. *Hum Toxicol*. 1987; 6(1):41.47. 10.1177/096032718700600107.

14 Senarathna L, Eddleston M, Wilks M, et al. Prediction of outcome after paraquat poisoning by measurement of the plasma paraquat concentration. *QJM*. 2009; 102(4):251.259. 10.1093/qjmed/hcp006.

15 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.

16 Sukumar CA, Shanbhag V, Shastry AB. Paraquat: The Poison Potion. Indian J Crit Care Med 2019;23(Suppl 4):S263–S266

17 Yang CJ, Lin JL, Lin-Tan DT, Weng CH, Hsu CW, Lee SY, Lee SH, Chang CM, Lin WR, Yen TH. Spectrum of toxic hepatitis following intentional paraquat ingestion: analysis of 187 cases. Liver Int. 2012 Oct; 32(9):1400-6. doi: 10.1111/j.1478-3231.2012. 02829. x. Epub 2012 Jun 5. PMID: 22672665.

18 Gheshlaghi F, Haghirzavareh J, Wong A, Golshiri P, Gheshlaghi S, Eizadi-Mood N. Prediction of mortality and morbidity following paraquat poisoning based on trend of liver and kidney injury. BMC Pharmacol Toxicol. 2022 Sep 6; 23(1):67. doi: 10.1186/s40360-022-00609-y. PMID: 36068596; PMCID: PMC9450277.

19 Fengjun J, Wen Z, Taoning W, Yaying Y, Kai K, Liu M. [Analysis of risk factors for prognosis of patients with acute paraquat intoxication]. Zhonghua Wei Zhong Bing Ji Jiu Yi Xue. 2015 Nov; 27(11):906-10. Chinese. PMID: 27132458.

20 Asaduzzaman M, Chando MR, Ahmed N, Rezwanul Islam KM, Alam MMJ, Roy S. Paraquat-induced acute kidney and liver injury: Case report of a survivor from Bangladesh. Clin Case Rep. 2021 Nov 6; 9(11):e05020. doi: 10.1002/ccr3.5020. PMID: 34765204; PMCID: PMC8572334.

21 Han J, Zhang Z, Yang S, Wang J, Yang X, Tan D. Betanin attenuates paraquat.induced liver toxicity through a mitochondrial pathway. *Food Chem Toxicol*. 2014; 70:100.106. 10.1016/j.fct.2014.04.038.

22 Hong SY, Yang DH, Hwang KY. Associations between laboratory parameters and outcome of paraquat poisoning. Toxicol Lett. 2000 Dec 20; 118(1-2):53-9. doi: 10.1016/s0378-4274(00)00264-2. PMID: 11137309.

23 Rao R, Bhat R, Pathadka S, Chenji SK, Dsouza S. Golden hours in severe paraquat poisoning-the role of early hemoperfusion therapy. J Clin DiagnosticRes. 2017; 11(2): OC06-OC08

24 Cavalli RD, Fletcher K. *In: Biochemical mechanisms of paraquat toxicity. Autor AP (Ed.)* New York: Academic Press; 1977. An effective treatment for paraquat poisoning; pp. 213–34.

25 Gao Y, Zhang X, Yang Y, Li W. Early haemoperfusion with continuous venovenous hemofiltration improves survival of acute paraquat poisoned patients. *J Int Med Res*. 2015; 43(1):26–32.