Section: Miscellaneous

Original Research Article

CLINICAL FEATURES, PROGNOSTIC FACTORS, AND OUTCOMES IN PARAQUAT POISONING: A PROSPECTIVE OBSERVATIONAL STUDY

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Abstract

Background: Paraquat (PQ) is a widely used herbicide in many parts of the world, especially in developing countries. Due to the absence of a specific antidote, paraquat poisoning results in high morbidity and mortality. The PQ metabolism generates free radicals, causing extensive damage to organs, with lungs being particularly affected. Multi-organ failure often results from the ingestion of significant quantities of PQ, leading to a high case-fatality rate. Despite its toxic potential, PQ continues to be used in various countries, with limited public awareness of its dangers. The objective is to examine the clinical features, laboratory parameters, and prognostic factors in patients with paraquat poisoning, and to assess the utility of the SOFA score in predicting the severity and outcome of poisoning cases. **Materials and Methods:** This was a prospective observational study conducted over two years at a tertiary care center. A total of 80 patients with confirmed PQ poisoning were included, after obtaining ethical approval and informed consent. Detailed histories, physical examinations, and laboratory assessments including renal and liver function tests, arterial blood gases, and chest X-rays were performed. The severity of poisoning was assessed using the SOFA score. Treatment included activated charcoal administration, gastric lavage, and hemodialysis when indicated. The outcomes were analyzed based on clinical complications and survival. **Result:** The majority of patients were aged 21-49 years (67.5%), with males accounting for 60% of cases. Most patients consumed between 10-20 ml of PQ (42.5%), with 43.75% seeking medical care within 12-24 hours of ingestion. Acute kidney injury (AKI) was observed in 65% of patients, while 37.5% experienced multi-organ failure. The mortality rate was 60%, and survivors exhibited significantly lower SOFA scores than non-survivors. Key laboratory findings, including pH, PO2, PCO2, HCO3, and neutrophil count, were significantly altered in non-survivors. Patients with higher SOFA scores had increased requirements for mechanical ventilation and hemodialysis. The study demonstrates that PQ poisoning predominantly affects younger adults and is associated with high rates of AKI, acute lung injury, and multi-organ failure. The SOFA score proved valuable in predicting the severity of poisoning and the need for critical interventions like mechanical ventilation and dialysis. Despite advances in supportive care, including hemodialysis and steroid therapy, mortality remains high, particularly in patients presenting with severe acidosis and organ dysfunction. **Conclusion:** Paraquat poisoning leads to significant morbidity and mortality, with multi-organ failure being a common outcome.

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The SOFA score is an effective tool for assessing prognosis in these patients. Early recognition and prompt supportive care are critical, but prevention through stricter regulations on PQ usage may be the most effective strategy to reduce fatalities.

INTRODUCTION

Paraquat (PQ, 1,1′-dimethyl-4,4′-bipyridinium) is a commonly used herbicide in India.[1-3] It is often associated with suicides, leading to significant morbidity and mortality due to the lack of a specific antidote. While there is no dedicated antidote, treatments typically involve steroids, cyclophosphamide, or antioxidants to help mitigate damage from free radicals.[1] PQ metabolism produces free radicals that damage cellular organelles and membranes, particularly affecting the pulmonary alveolar epithelium.[4] PQ can induce multi-organ failure affecting the lungs, gastrointestinal tract, pancreas, kidneys, liver, heart, and brain.[5,6] Ingesting more than 40 mg/kg of PQ generally results in acute multi-organ failure with death occurring within the first 2 days, whereas ingestion of less than 20 mg/kg usually results in milder symptoms with higher survival rates.[7] Doses between 20–40 mg/kg cause severe mucosal damage and multi-organ failure, with survivors often dying within 2–4 weeks due to lung fibrosis. PQ accumulates in pulmonary alveolar cells due to its structural similarity to polyamines, leading to delayed lung injury.[8] The case fatality rate is between 40–60%, with death typically occurring within 24–72 hours in severe cases.[4]

Despite its adverse effects, PQ continues to be widely used in various parts of the world. Public awareness regarding its toxicity is limited. In the USA, PQ is classified as a Highly Hazardous substance and is banned due to risks of accidental or intentional exposure. Existing data on PQ poisoning is largely confined to case reports and small series. This study aims to examine the clinical features and outcomes of PQ poisoning and to explore predictors of severity and outcome in relation to the SOFA score.

MATERIALS AND METHODS

This prospective observational study was conducted over a 2-year period involving patients of either sex admitted to a tertiary care centre with a history of paraquat poisoning, following institutional ethical approval and informed consent. Patients with exposure to other poisons, pre-existing lung, liver, or kidney diseases, malignancies, or those who did not consent were excluded. The study included 80 patients who met the criteria.

Patients were assessed through a detailed history of poison consumption, including the amount, concentration, and time elapsed from ingestion to hospital admission. Comprehensive physical and systemic examinations were performed, and diagnostic tests including renal function tests, liver function tests, prothrombin time, arterial blood gas analysis, and chest X-rays were conducted. The severity of poisoning was evaluated using the SOFA score and relevant laboratory data.

All patients received 1g/kg of activated charcoal via a nasogastric tube following gastric lavage with normal saline in the emergency department. Renal and liver function tests were repeated every alternate day post-treatment initiation. Hemodialysis was performed as necessary for patients with significant renal impairment. Multiorgan failure was identified in patients with serum creatinine > 2 mg/dl, alanine transaminase (ALT) > 80U/L, or International Normalized Ratio (INR) > 1.5. Acute lung injury was defined as a PaO2 < 70 mmHg on arterial blood gas analysis.

RESULTS

The majority of the participants were aged between 21-49 years (67.5%), followed by those over 50 years (20%) and those under 20 years (12.5%). The mean age of the participants was 41.77 ± 12.7 years, ranging from 19 to 65 years. The study had 48 male participants, while 32 were female.

Regarding the quantity of paraquat ingested, 42.5% of the patients consumed between 10-20 ml. In terms of time to hospital admission, 43.75% of patients were admitted within 12-24 hours, 37.5% after more than 24 hours, and 18.75% within 12 hours. Hospital stay durations varied, with 32 patients staying 0-2 days, 13 staying 2-4 days, and 35 staying more than 4 days. Complications observed included metabolic acidosis in 16 patients, acute kidney injury in 52 patients, and acute lung injury in 16 patients. In total, 48 patients survived. [Table 1]

The ABG analysis upon admission revealed that pH, PO2, PCO2, and HCO3 levels were significantly higher in patients who did not survive compared to those who did. Although the PaO2/FiO2 ratio was slightly elevated in patients who died compared to those who survived, this difference was not statistically significant [Table 2].

Additionally, the mean neutrophil count was significantly higher, while the mean hemoglobin level was notably lower in deceased patients compared to survivors. Differences observed in other hematological parameters between those who survived and those who did not were not statistically significant [Table 3].

The amount of paraquat ingested did not show a statistically significant difference in the survival outcome [Table 4].

However, the mean SOFA score was significantly higher in patients who required mechanical ventilation, underwent hemodialysis, and ultimately died, compared to those who did not need such interventions and survived [Table 5].

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Table 1: Socio-demographics characteristics and other variables of study participants.

Parameters	Sub- group	Frequency	Percentage
Age in years	Less than 20 years	10	12.5
	21– 49 years	54	67.5
	50 years and above	16	20
Age (years) Mean ± SD/ range		41.77 ± 12.7 years/ 19-65 years	
Sex	Male	48	60
	Female	32	40
Amount consumed	5 – 10 ml	24	30
	11-20 ml	34	42.5
	>20ml	22	27.5
Time from paraquat consumption to arrival at hospital (in hours)	Less than 12	15	18.75
	12-24	35	43.75
	24 and more	30	37.5
Duration of hospital stay	0 – 2 days	32	40
	2-4 days	13	16.25
	>4 days	35	43.75
Complications	Metabolic Acidosis	16	20
	AKI	52	65
	ALI	16	20
	Multiple Organ Damage	30	37.5
Outcome	Survived	32	40
	Dead	48	60

Table 2: Biochemical parameters of study participants with the survival status

Biochemical Parameters	Dead		Survived		Independent t test P-value
	Mean	SD	Mean	SD	
PH	6.10	0.70	7.93	1.10	0.01
PO2	90.11	6.99	89.67	1.29	<0.001
PCO2	39.59	5.01	35.54	2.49	0.0001
HCO3	19.50	3.11	23.52	1.86	0.003
PaO2/FiO2	401.78	09.65	336.22	12.42	0.43

Table 3: Relationship of Hematological Parameters on admission with Mortality.

Hematological Parameters	Dead		Survived		P Value*
	Mean	SD	Mean	SD	
Neutrophils	6599	2238.31	3799.98	1451.79	0.0001
Lymphocytes	2551	1116.30	2333.00	98.81	0.118
Platelets	2.34	0.79	2.49	0.89	0.300
Hb	9.99	1.49	11.86	1.71	0.036
BUN	16.79	9.89	19.99	7.54	0.492
Sr. Creatinine	1.46	0.69	1.28	0.44	0.304
Sr. Bilirubin	1.41	1.12	1.33	0.43	0.516
CRP	4.82	0.89	4.61	0.69	0.899
MAP	82.33	7.45	85.19	8.79	0.200

*Independent t test

Table 4: Total amount of paraquat ingested.

Amount consumed(ml)	Survived N (%)	Dead N (%)	Total	P value*
5-10	11 (34.37)	13 (27.08)	24 (30)	0.99
5-20	13 (40.62)	21 (43.75)	34 (42.5)	
>20	8 (25)	14 (29.16)	22 (27.5)	
Total	32 (40)	48 (60)	80 (100)	

Table 5: SOFA at various clinical situations and management

Variables	Sub group	SOFA Mean	SOFA SD	P value
On admission	Alive	5.88	5.83	0.873
	Dead	5.66	2.29	
Mechanical ventilation at 48 hrs	Yes	7.91	1.37	<0.001
	No	3.94	1.34	
Haemodialysis at 48 hours	Yes	6.09	2.42	0.031
	No	4	1.51	
Outcome	Dead	10.75	6.65	<0.0001
	Alive	2.63	1.09	

DISCUSSION

Paraquat remains easily accessible and cost-effective in many developing nations, leading to its prevalent use in self-harm cases. This has resulted in a high fatality rate due to the unavailability of an effective antidote. Our study aimed to evaluate the clinical features, laboratory findings, and key prognostic factors linked with paraquat poisoning.

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In this study, the majority of paraquat poisoning cases (67.5%) were observed in individuals aged 21 to 49 years, with 20% of the cases involving those over 50. The average age was 41.77 years, ranging from 19 to 65 years. This finding contrasts with Ravichandran et al., who reported a median age of 28 years,[1] and Jagadeesham et al., who documented a median age of 28.5 years.[9] Similarly, Raghavendra Rao et al. found a mean age of 26 ± 7.679 years and a median age of 26 years.[10] The higher incidence of paraquat ingestion in younger individuals might be associated with impulsive behaviors, and understanding these demographic patterns could assist in developing more focused prevention strategies.

In our study, males accounted for a higher percentage (48 male and 32 female patients), aligning with previous findings such as Ravichandran et al., where 65.4% were male,[1] and Jagadeesham et al., where 80% were male.[9] Likewise, Raghavendra Rao et al. reported around 65% of the cases involving males.[10] The higher involvement of males in occupations like pesticide application in Southern India may explain this gender imbalance.

The volume of paraquat ingestion varied, with 24 patients consuming less than 10 ml, and 22 patients ingesting more than 20 ml. Ravichandran et al. noted that 54.5% of their cases involved ingestion of moderate amounts, with patients presenting 6–12 hours after ingestion.[1] Our findings, like those of Narcisse Elenga et al. (2018), indicate that larger amounts ingested correlate with more severe complications, including increased need for mechanical ventilation and hemodialysis.[11] Furthermore, patients who consumed larger volumes had elevated SOFA scores, indicating a poorer prognosis.

The mortality rate in our study was 48 patients, which is similar to the 61.4% mortality reported by Rao et al. in a study of 101 patients.[12] Ravichandran et al. noted a higher mortality rate of 72.5%, with some fatalities occurring post-discharge due to delayed pulmonary fibrosis.[1] Other studies have reported mortality rates ranging from 66.7% to 100%.[9,12–15]

Only 15 patients in our study presented to the hospital within 12 hours of poisoning, while the majority sought medical care after 24 hours. Previous research, including that of Cheng-Hao Weng et al. (2017), identified delayed hospital arrival as a negative prognostic indicator.[18] However, in our study, time to hospital arrival did not emerge as an independent risk factor, possibly due to differences in the volume of paraquat ingested.

Acute kidney injury (AKI) occurred in approximately 84% of patients, with 20 deaths occurring within 48 hours despite hemodialysis. Additionally, 30% of patients developed acute respiratory distress syndrome (ARDS) and required mechanical ventilation, with fatalities occurring within the first 48 hours. This is consistent with findings by Gawarammana et al., who noted paraquat's tendency to rapidly accumulate in the lungs and kidneys.[4] High SOFA scores were frequently associated with ARDS and mechanical ventilation.

Patients who ingested larger volumes of paraquat exhibited lower pH, PaO2, PCO2, and HCO3- levels, often resulting in metabolic acidosis secondary to AKI. These findings suggest that paraquat poisoning leads to significant hypoxemia and acidosis. Changbao Huang et al. (2011) reported that lower PCO2 and HCO3- levels in deceased patients were significant indicators of severity.[19] Additionally, leucocytosis was observed, likely as part of the body's inflammatory response.

At admission, 14 patients had SOFA scores ranging from 5 to 21, and these patients did not survive beyond 48 hours. High SOFA scores were strongly associated with larger volumes of ingested paraquat. At 48 hours, 12 patients required mechanical ventilation due to severe hypoxia and high SOFA scores, while 22 patients needed hemodialysis. However, by day 7, 10 patients survived, including two who had high SOFA scores and recovered after undergoing hemodialysis. Higher mortality was consistently observed in patients with elevated SOFA scores. Research by Wen Jie Wang et al. highlights that increased SOFA scores are closely linked with higher mortality in paraquat poisoning cases.[19] Thus, the SOFA score is a valuable tool for assessing prognosis in these patients.

CONCLUSION

Paraquat poisoning is characterized by leucocytosis, thrombocytopenia, elevated CRP levels, AKI, acute lung injury (ALI), ARDS, metabolic acidosis, and multiple organ dysfunction syndrome (MODS). The SOFA score serves as an important prognostic tool for predicting complications such as AKI, ARDS, and the need for mechanical ventilation and hemodialysis. Despite advances in treatment, including hemodialysis, steroid pulse therapy, antioxidant therapy, and mechanical ventilation, mortality remains high. Increased awareness among clinicians and improved diagnostic measures may enhance outcomes. In the absence of a definitive cure, restricting paraquat's availability and use is the most effective preventive strategy.

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