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Complete recovery from paraquat poisoning causing severe unilateral pulmonary lesion

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Poisoning by paraquat, a plant-protecting agent, its clinical manifestations and treatment are discussed. The case of a 5-year-old boy who had ingested an unknown quantity of paraquat is described. Peritoneal dialysis proved to be effective in overcoming renal and hepatic failure. Subsequently, a pulmonary lesion with unilateral preponderance developed; this showed marked radiological regression and in a year nearly complete functional recovery ensued.

Paraquat was synthesized during the last century and has been used as an oxidoreduction indicator in chemistry [4]. Since the sixties of this century it has been utilised as a plant-protective agent, in granulated form, or 20 % solution in aerosol. Its aqueous solution is reddish-brown in colour, and may be mistaken for beer or Coca-cola. Paraquat is a quaternary bipiridyl cation, it inhibits the conversion of NADP to NADPH in the cells, and induces damage to the cell membrane by polymerising the unsaturated lipids.

Since 1966, several hundred papers reported on accidental or suicidal paraquat poisoning. Most frequently, the agent enters the organism orally; its aerosol may penetrate the skin at plant spraying [13, 23] or directly invade the airways [8]. Absorption of the orally ingested agent is poor, only 1—5 % is absorbed, the rest is excreted with the stools [4, 11, 15]. The major part of the absorbed paraquat is excreted by the kidneys, a small proportion appears in the bile; the pathogenesis of renal and hepatic damage is thus obvious. A third target organ is the lung [24], the paraquat concentration in the pulmonary tissue exceeds about fifty times that of the plasma. This explains the occurrence of severe pulmonary complications.

Paraquat can be demonstrated in the urine and this test may be of use in judging the effect of treatment. Knowledge of the blood level may also be useful. It can be measured by spectrophotometry, ion exchange, gas chromatography and RIA [4, 10, 14, 21, 22]. A blood level exceeding 0.1—0.2 μg/ml is usually lethal within 24—48 hours, but exceptional survivors displaying higher levels have also been described [10, 15, 21]. The mortality rate is very high, amounting to 33—60 % [3, 4, 24].

Ingestion of 6—10 g paraquat leads to convulsions, pulmonary oedema, shock and death within several hours or a few days. Smaller doses cause burning sensation in the mouth, oesophageal erosions and sometimes perforation [1], abdominal pain and hepatic and renal failure followed by adult respiratory distress syndrome ending in death. Cellular damage may occur in the adrenal glands manifesting with cortical necrosis [20]. If smaller doses are ingested, the pulmonary changes ensue only after 2 or 3 weeks. They consist of oedema, damage to the alveolar epithelium, haemorrhage, atelectasis, infiltrates, pleural effusions, bullous changes and ultimately alveolar and interstitial fibrosis [2, 4, 7, 11, 24, 26]. These changes can be followed radiologically and by pulmonary function tests [8, 17]. Time is the most important factor in therapy: the mortality rate of cases whose treatment was started beyond the first five hours after ingestion of the agent was as high as 64% as observed in a material of 68 cases [12]. First aid comprises binding of the agent to prevent its absorption application of an emetic, cautious gastric lavage (danger of perforation!), administration of Fuller's earth and purgation. The second step is elimination of the poison by forced diuresis [10, 21], haemoperfusion [19, 21, 23, 27], haemodialysis, plasmapheresis [5] or peritoneal dialysis [15]. Administration of ascorbic acid may be of benefit [9]; steroids or even immunosuppressive drugs have been attempted for prevention of pulmonary damage [4, 15]. In addition, administration of air with a low oxygen concentration not exceeding 20% even in hypoxia has been recommended; breathing of nitrogen gas may be useful in preventing or slowing down the oxidative process initiated by paraquat [6, 21].

Report of a Case

P. K., a five-year-old boy, was admitted on 18 May, 1982. Three days earlier he had drunk an unknown quantity of 20% paraquat solution. On the next day he had vomited but the general practitioner did not find any abnormality. On the following day he had had haematemesis and was admitted to a country hospital. There the oral erosions and haematemesis suggested some poisoning and then the parents remembered that the child may have drunk of the plant-protecting agent. Gastric lavage was performed, Fuller's earth was administered and the child was admitted to our department.

At admission the child was azotaemic, with a blood urea nitrogen level of 39.8 mmol/l and a serum creatinine of 465 μmol/l. Chest X-rays revealed no abnormality and all other laboratory findings were normal. Only traces of paraquat could be shown in blood and urine taken at the time of admission. In view of the renal failure peritoneal dialysis was instituted; it was terminated after five days when the blood urea nitrogen and creatinine levels had returned to normal values. On the fifth day of treatment slight jaundice appeared, laboratory findings revealed mild hepatic damage (serum GOT, 82 U/l; GPT, 52 U/l; serum bilirubin, 13 μmol/l). On the seventh day, tachypnoea of 70—80 per minute set in and repeated chest X-rays showed a large infiltration in the whole right lung, with a minor infiltrate in the left lung (Fig 1). A high dose of methylprednisolone (250 mg per day), later daily 20 mg dexamethasone, antibiotics and 20% oxygen were administered; lower oxygen concentrations were not applied as the pO_2 value was low.

The patient's condition improved gradually, the respiration rate diminished. Chest X-rays on the 46th day showed mediastinal dislocation to the right, rarefaction within the right lung and several

bullae could be demonstrated by tomography (Figs 2, 3). Increased transparence of the left lung accompanied by a fascicular pattern in the basal parts was then found. Treatment was complemented by administration of atomised mucosolvents and steroids, the dose of oral corticosteroids was gradually diminished.

Pulmonary scintigraphy, carried out after the acute phase, showed markedly decreased perfusion in the right lung, with complete absence of activity in the apical region. The effective capillary perfusion of the right lung was 25—30% of that of the left lung (the normal proportion is right: left = 60—55%:40—45%).

Repeated lung function tests pointed to the possibility of pulmonary fibrosis: forced vital capacity (FVC) was markedly depressed, intrathoracal gas volume (IGV) and tidal volume (TV) showed low values. All lung function findings are shown in Table I.

After termination of corticosteroid treatment, aerosol therapy was complemented with respiratory exercises. The patient was discharged with normal respiratory rate and normal renal and hepatic function tests on the 84th day after admission.

At home respiratory exercise was prescribed and the patient was regularly followed at the clinic. Blood gas analysis and bicycle ergometry revealed normal values. The parents reported on normal activities of the boy at home, lung function tests demonstrated gradual improvement. By the end of the first year all values reached or exceeded the lower limit of normal. A second lung scintigraphy demonstrated reduced perfusion but the improvement was striking (Fig. 4). The chest X-rays also revealed gradual improvement and on 15 August, 1983, they showed the mediastinum in nearly normal position and a nearly normal translucency of the right lung (Fig. 5).

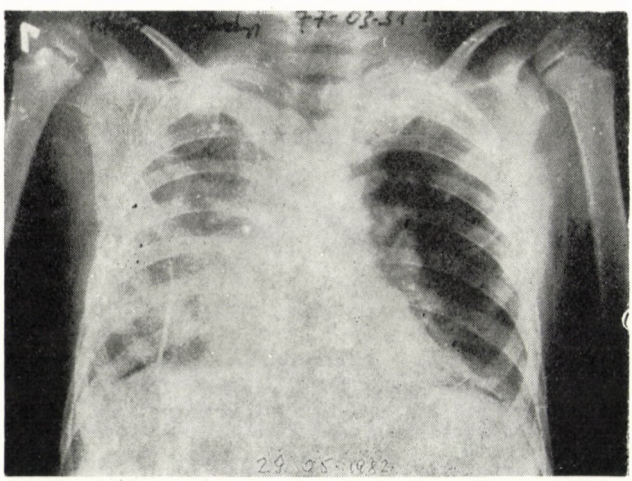


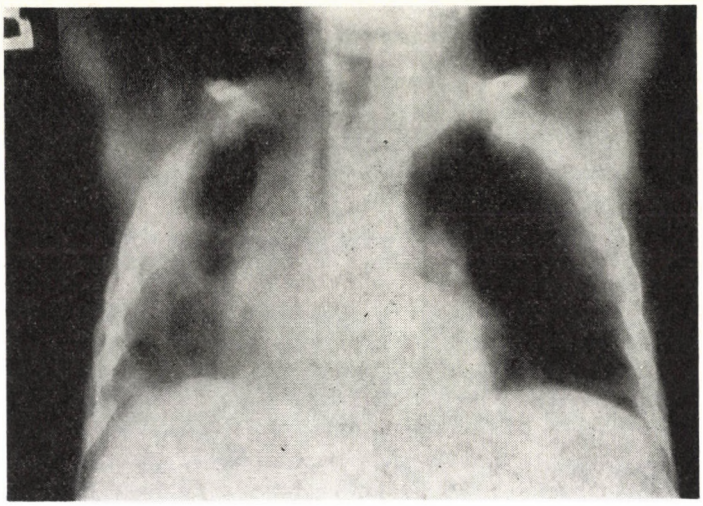
FIG. 1. Chest X-rays 10 days after ingestion of paraquat: massive infiltration of whole right lung, moderate infiltrate on left side

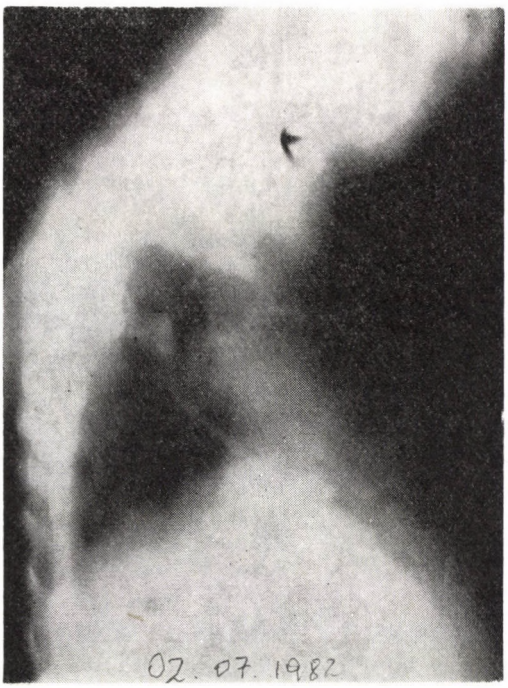
TABLE I

Results of lung function tests

	FVC		FEV		PEFR		R		IGV	
	ml	percent	ml	percent	l/sec	percent	mbar/l/sec	percent	ml	percent
29 June, 1982	662	(45)	424	(35)	1.44	(49)	—	—	—	—
9 August, 1982	896	(61)	666	(55.5)	1.86	(63.4)	17.25	(297)	315	(39)
12 April, 1983	1125	(77.5)	923	(77)	3.09	(105)	5.8	(100)	932	(116)
15 August, 1983	1120	(77)	980	(79)	3.02	(104)	5.7	(99)	926	(115)

Figures in brackets: percentage of the corresponding normal value





FIGS 2. 3. Tomography on 46th day: bullous changes in right lung, the mediastinum is dislocated to the right

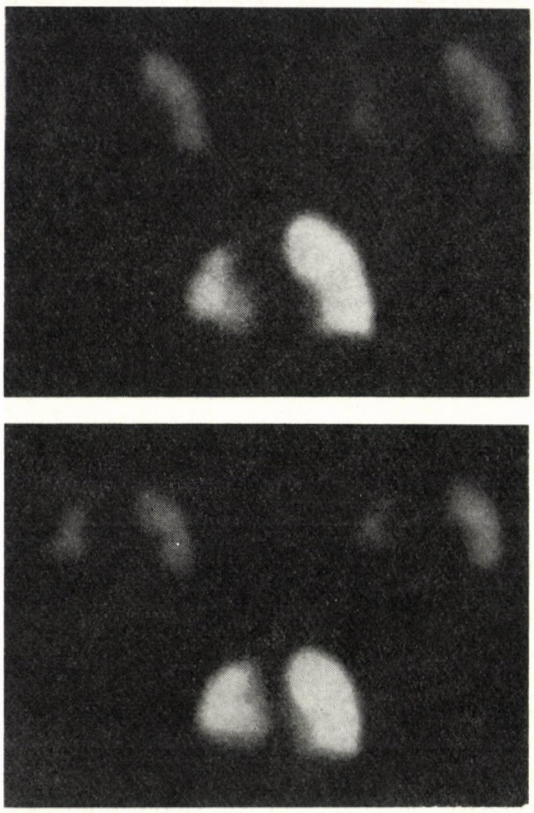


FIG. 4. Scintigraphy, immediately after the acute phase: very marked diminution on right side. After half a year: distinct improvement

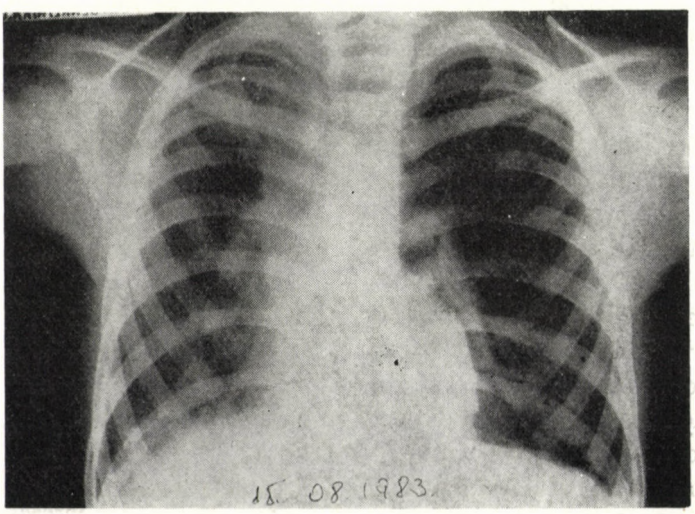


FIG. 5. X-rays on 15 August, 1983: nearly normal finding, the mediastinal dislocation has almost completely disappeared, increased transparency of right lung

Discussion

In spite of improvement of the therapeutic methods applied in paraquat poisoning, the quantity ingested and the time of introduction of treatment are the factors determining the outcome. In our case the ingested quantity of paraquat remained unknown, it may however, be anticipated, that it had not been within the lethal range. The symptoms showed a comparatively late onset, the administration of Fuller's earth could not have been effective [12].

In this situation treatment of renal failure and the liver damage seemed of primary importance; haemoperfusion was not done because only traces of paraquat could be found in the patient's blood and urine. Steroid treatment introduced at admission did not prevent the development of pulmonary damage although it has been recommended for this purpose [4, 8, 21]. Mahieu et al [15] succeeded in preventing pulmonary damage by bleomycin, forced diuresis and peritoneal dialysis. In our patient the pulmonary complication was nearly completely restricted to the right lung, as confirmed by X-rays and scintigraphy; bullous changes developed in addition.

We have been unable to find any report on recovery from a pulmonary complication as severe as seen in our case. In the case described by George and Hedworth-Whitty [8] pain in the chest, dyspnoea and abnormal auscultation findings ensued after inhalation of paraquat aerosol but as the X-rays revealed no abnormalities in spite of diminished FEV_1, VC and PEFR values, they thought of interstitial damage (fibrosis?). In the literature there are descriptions on 8 paediatric cases of paraquat intoxication; two of them died, in the other six patients there were no pulmonary complications demonstrable by X-rays or lung function tests [18, 23, 25]. The toxic effect of oxygen in paraquat poisoning has long been known; in an environment rich in oxygen the free paraquat radicals induce cellular damage, primarily to the pneumocytes. In addition, the drug radicals initiate superoxide formation as well [3, 4, 6]. On the basis of these findings, administration of low (10—20%) oxygen concentrations has been recommended for treatment of hypoxaemia. In our case, we applied 20% oxygen for a short time.

In our opinion the unilateral complication itself and its nearly complete healing, as demonstrated by X-rays, scintigraphy and lung function tests carried out repeatedly during the one-year follow-up, were unique features of the case presented. The explanation of this rare event may lie in the better regenerative power of children.

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