
Nail damage in spray operators exposed to paraquat

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Hearn, C. E. D., and Keir, W. (1971). *Brit. J. industr. Med.*, 28, 399-403. **Nail damage in spray operators exposed to paraquat.** Nail damage in 55 persons due to contamination by diluted paraquat in a group of 296 spray operators employed on a sugar estate in Trinidad is described.

The commonest lesion seen was transverse white bands of discoloration, but loss of nail surface, transverse ridging, gross deformity of the nail plate, and loss of nails occurred. The index, middle, and ring fingers of the right hand were predominantly affected and this could be ascribed to leakage from the knapsack sprayer.

It is emphasized that, although the degree of contamination was unusually gross, it is nonetheless important to recognize that the diluted material can cause nail damage. Simple hygienic precautions and proper maintenance of spraying equipment can prevent its occurrence. Periodic medical examinations are recommended even for workers exposed only to diluted paraquat.

The distribution of the nail lesions confirms that they are the result of a local action. Following cessation of further exposure subsequent nail growth is normal.

The dipyrilidilium herbicides paraquat (Gramoxone) and diquat (Reglone) have been extensively used in all parts of the world for weed control and also as defoliant before harvesting, e.g., potatoes and cotton. They have an immediate action on plants but are quickly inactivated on contact with most soils. Paraquat also has uses in the chemical renovation of degraded pastures that can even remove the need for the plough.

In use in agriculture since 1961, the safety of paraquat even under extreme working conditions has been amply demonstrated (Swan, 1969). Fifty-six accidental fatalities have been reported since 1964 (Bullivant, 1966; Campbell, 1968; Matthew, Logan, Woodruff, and Heard, 1968; Masterson and Roche, 1970; and others). Apart from one bizarre incident of suicide by subcutaneous injection (Almog and Tal, 1967), all accidental ingestion has occurred because the herbicide has been thoughtlessly decanted into an old and usually unlabelled beverage

bottle. One instance of eye damage due to splashes from the concentrate has been recorded (Cant and Lewis, 1968), while the very rare incidence of skin reactions has been stressed (Swan, 1967).

Only three examples of nail damage due to paraquat have been reported (Samman and Johnston, 1969) and these have followed contamination with the concentrate (either Gramoxone or Preeglone Extra which contains both paraquat and diquat). It is extremely rare for the diluted material to cause such an effect (Swan, personal communication) and no instances have been reported.

Nail damage following contamination with diluted paraquat occurring in 55 spray operators employed on a sugar estate in Trinidad is reported. It must be emphasized that the degree of contamination was unusually gross.

Population and methods

A survey of 296 spray operators employed on a sugar estate in Trinidad was carried out following the occurrence of a few cases of nail damage in the men exposed. Periodic examinations of the exposed persons had been

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undertaken during previous spraying seasons but had been discontinued as they were considered unnecessary in workers exposed only to diluted material. The operators consisted of 269 Indians and 27 Negroes. The Indians in this study are descendants of indentured immigrants brought into Trinidad between 1844 and 1917 to relieve the labour shortage that occurred on the plantations after the abolition of slavery. They came from two ports of exit in India, Calcutta and Madras. The Negroes are West African in origin.

The standard clothing of the sprayers consisted of shirt and long trousers tucked into gum boots. In a minority of hilly areas no footwear was worn as the employee regarded the more secure foothold afforded by the exposed toes as essential for his equilibrium. The mixers handling the concentrated material wore face shields and rubber gloves. Washing facilities were readily available in case of accidental contamination and at the end of the day's work. Twenty separate teams of sprayers operated in different sections of the estate, widely scattered over 52,000 acres under cultivation, there being one mixer attached to each team. Only the mixer handled the concentrated paraquat, making up a standard 1:100 to 1:200 dilution. Seventy per cent of the paraquat used was applied in this form. The remaining 30% was used in a mixture with 2-4 dichlorophenoxyacetic acid (2, 4-D) (1:200 dilution) or diuron (1:200 dilution).

Saval knapsack sprayers with 'flood-jet' nozzles were used. Although spraying operations were carried out from February until October for approximately five to six hours per day on three days in each week, only a limited proportion of this time involved exposure to paraquat. The remaining time was spent in the application of standard pre-emergence herbicides, e.g., a mixture of 2-methyl-4-chlorophenoxyacetic acid and 2,3,6-trichlorbenzoic acid ('Pesco 1815'), atrazine, and diuron. There was, moreover, a large element of casual labour, some sprayers being employed for very limited periods during this time. In any one team perhaps only 50% would be regularly employed on spraying throughout the year. The analysis of exposure to paraquat has therefore been restricted to the affected employees only.

Although the majority of workers consistently used the right hand to hold the spraying lance and operated the pump handle with the left hand, some interchanged their hands during the day as the pumping hand became tired. In addition, all operators assisted in the loading of their knapsack sprayers themselves and so could have had both hands exposed to the diluted chemical for a limited period.

Description of nail lesions

The earliest lesion seen was a localized white, occasionally yellow, discoloration of the base of the finger nail resembling initially an exceptionally well-defined lunule. The commonest lesion was transverse white bands of discoloration affecting one or more nails (Fig. 1). Progressive nail deformity then ensued with loss of nail surface and irregularity of the surface with transverse ridging and furrowing. Increasingly irregular and bizarre deformity of the whole nail plate with loosening and commencing separation of the nail then occurred, the nail



FIG. 1. Transverse white bands of discoloration on nails.

ultimately being shed (Fig. 2). Increased pigmentation of the skin round the base of the nail was also a feature and may be seen in Figure 2. Similar but less pronounced lesions were seen in the toe nails.

Five grades of severity of nail damage were recognized:

- Grade I Localized discoloration, or transverse bands of white discoloration affecting one nail only
- Grade II Transverse bands of white discoloration affecting two or more nails
- Grade III Nail deformity, whether loss of nail surface, irregularity of surface, or transverse ridging and furrowing
- Grade IV Grossly irregular deformity of nail plate and/or loosening and commencing separation of the nail
- Grade V Loss of nail



FIG. 2. Total loss of nail of right index finger, grossly irregular deformity of nail plate of middle finger, and discoloration, ridging, and commencing separation at base of ring finger nail. Increased pigmentation of skin at base of nails.

Results

It can be seen from Table 1 that the quantity of paraquat applied has risen steadily during the period 1966 to 1970. The number of spray operators employed in the different sections, the quantity of paraquat applied, and the number of individuals

TABLE 1
QUANTITY OF CONCENTRATED PARAQUAT APPLIED
DURING THE PERIOD 1966-70

	1966	1967	1968	1969	1970
Concentrated paraquat applied (gallons)	390	641	2 726	4 819	6 541

with nail damage are shown in Table 2. Three mixers were mildly affected but, as they were exposed to the concentrated chemical, mixers have not been included in the analysis. Of the 55 affected spray operators exposed to diluted paraquat only, the right hand was involved in 33, the left in 13, and both hands in nine. The index, middle, and ring fingers, either singly or collectively, were affected in all 33 workers whose right hand was involved, and there

TABLE 2
PREVALENCE OF FINGER-NAIL DAMAGE IN SPRAY
OPERATORS AND QUANTITY OF PARAQUAT APPLIED
IN SECTION

Section	Concentrated paraquat applied in 1970 (gallons)	No. employed	Nail damage
Curepe	225	10	3
Wilderness	225	10	1
Jerningham Junction	227	6	1
Woodford Lodge	130	7	1
Edinburgh	411	15	2
Felicite	145	21	1
Waterloo	730	29	5
Exchange	650	36	2
Brechin Castle	170	13	6
Montserrat	420	13	6
Esperanza	860	16	5
Phoenix Park	442	15	11
Reform	163	10	2
Cedar Hill	371	14	—
Bronte	20	13	—
Picton	201	15	1
La Fortunee	278	15	4
Williamsville	273	17	3
La Gloria	440	12	1
Petit Morne	160	14	—
	6 541	296	55

was a similar distribution in the 13 workers whose left hand was involved.

The mean total diluted paraquat applied, the mean amount sprayed per week, and the man-days exposed are given in Table 3, together with their ranges and standard deviations. The relationship between the severity of the nail lesions and the total amount sprayed was examined but there was insignificant correlation ($r = +0.287$), nor was there any significant relationship between the severity and the amount sprayed per week or the man-days exposed.

TABLE 3
EXPOSURE TO PARAQUAT OF AFFECTED 55 SPRAY
OPERATORS

	Mean	Range	S.D.
Total diluted paraquat sprayed (gallons)	3 429	450-6 600	1 811.8
Amount sprayed per week (gallons)	145	118-161	12.8
Man-days exposed	72	9-132	36.1

S.D. = standard deviation

The number of affected sprayers with the different grades of severity of nail lesions is shown in Table 4.

Eleven of the affected spray operators also showed minor nail damage affecting the toes. The right foot was involved in three, the left in two, and both in six. In four instances the lesions were of grade I severity, and in seven of grade II. In all instances where the toes were affected the sprayers had worn gum boots. No sprayer who habitually worked barefoot showed any damage to the toe nails.

There were two cases with a mild desquamative eruption on the hands, but without any evidence of nail damage, which subsided rapidly. No instances of eye irritation from spray entering the eyes were seen.

TABLE 4
NUMBER OF AFFECTED SPRAY OPERATORS IN THE
DIFFERENT GRADES OF SEVERITY

Grade of severity	No. affected
I	22
II	16
III	6
IV	6
V	5

the spray might be thought important in a hot climate (mean temperature 29°C (84°F)), this factor would be considerably limited by the high relative humidity (80 to 90%).

The occurrence of such a high incidence of nail damage suggests the need for the continuance of periodic medical examinations, even in workers exposed only to the diluted material, as a means of detecting unsatisfactory working conditions.

It is of interest that the only cases of toe-nail damage occurred in workers wearing gum boots, suggesting leakage from the sprayer down into the boots, and it is also perhaps an indication of unusual carelessness in application. Toe-nail damage has, however, been encountered in barefoot sprayers on coffee plantations in Kenya (Swan, personal communication). The absence of either nose bleeding or eye irritation in any operator is noteworthy, as is the occurrence of only two cases of mild skin eruption. Swan (1969) reported that approximately half the men employed in his trials had some irritation of the skin or eyes at some time.

In the differential diagnosis, special consideration must be given to trauma which can also give rise to similar transverse ridging. White banding of the nails may be seen in malnourished coloured patients, but the distribution of the lesions and the history of exposure will differentiate. Candida infection, ringworm, psoriasis, and chronic lichen planus affecting the nails have their own characteristic features, but the possibility of paraquat damage should be borne in mind when considering the differential diagnosis of diseases of the nail.

It should be stressed that the degree of contamination with diluted paraquat was both gross and pro-

longed, and that the continued implementation of the simplest precautions could have prevented the occurrence of nail damage. The distribution of the lesions confirms that the nail damage is the result of a local action, the chemical collecting in the nail fold and affecting the nail matrix. Actual nail loss appeared more likely to result if infection subsequently occurred. Finally, in every instance following cessation of further contamination, subsequent nail growth was normal.

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