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Editorials

ROBERT B. O'CONNER, M.D.
Department Editor

A New Occupational Disease Is Born

The appearance of a new and striking occupational disease should stir up excitement equal to that among the astronomers when a new comet is discovered. Actually, that does not happen. A new occupational disease *has* appeared but, except for those directly involved, the excitement aroused has been distinctly less than that over the first crocus of springtime.

The new occupational disease is acroosteolysis. This disease is limited to one industry: to the manufacture of a single chemical; and to a single step in the manufacturing process. The industry is the chemical industry; the chemical involved is polyvinyl chloride; and the manufacturing step is the scraping of the reactor vessel walls after the emptying of every batch.

This disease begins with Raynaud's phenomenon which is its characteristic manifestation accompanied or followed by bony dissolution in the distal end of one or more fingers. Occasionally, bony dissolution has occurred elsewhere such as knee caps and iliac bones. On an irregular basis, scleroderma arises and, even less frequently, tinnitus; and there may be some evidence of parathyroid gland disturbances.

In this country, 34 plants manufacture polyvinyl chloride. Perhaps no two plants utilize the same processes and the same array of ancillary chemicals but all cases have appeared in those plants engaged in the manual scraping of the reactor walls. As many as 227 ancillary chemicals are introduced into the reactors but not more than 25 in any one operation. Other plants that resort to chemical solution of the wall residue have suffered no cases.

The first case of acroosteolysis (AOL) was reported in 1963 but not until the near present time has this disease become commonplace. In one study just completed, which was comprehensive as to this country's total number of plants, 33 cases were recognized subject to the possible addition of numerous borderline cases.

Through what portal the offending chemical enters the body, whether by skin or the respiratory tract, is unknown. Likewise, the minimal length of exposure necessary to causation is not established, but cases have appeared within 30 days of exposure.

The precise chemical or combination of chemicals leading to this disease is unknown. The manufacture of polyvinyl chloride starts with the entry of the monomer vinyl chloride into the reactor. At the present time, there are incomplete indications that the monomer itself is the cause of the affection. In the manufacture of the monomer, some instances of Raynaud's phenomenon have arisen, but in human beings bony destruction has not appeared. Continually, it is stated that the fully polymerized compound is completely inert. A large number of workers exposed only to the granular completed product have been examined by x-ray and there has been no detection of the disease. However, in one illy explored occurrence, a woman worker exposed only for five days to the finished polyvinyl chloride in molten state and working under circumstances that involved cooling with methyl chloride, promptly acquired acroosteolysis along with scleroderma and subsequently died. This instance provides uncertainty that the fully polymerized chemical is completely inert under all circumstances. At this time, it is generally accepted that the polymer is without physiologic action.

Thus, a new occupational disease is born but not yet has it been fully explored; not yet is its cause precisely known; not yet is the portal of entry established; not yet are any therapeutic measures known.

This new and characteristic occupational disease is to be added to the sum total of occupational diseases approaching 3,000, but of that large number the majority are trivial in consequence and some are rare. In the case of acroosteolysis, that new disease is not rare and, always, its occurrence is significant. It is associated with the manufacture of a widely used plastic, daily seen by most of the public. However, the public in no way is threatened by the advent of this new disease entity.

—Carey P. McCord, M.D.

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Istituto di Patologia General dell'Universita di Perugia
Direttore: Prof. A. Caputo

PATHOLOGY OF VINYL CHLORIDE

P. L. Viola

During the last years a syndrome characterized by alterations of the skeleton, teguments, nervous system and hepatic function[1, 2, 3, 4, 5, 6] has been observed among the workmen associated with vinyl chloride polymerisation process. An experimental programme has been performed in order to evaluate the toxic effect of vinyl chloride on the animal organism, and in order to try to reproduce in rats the acroosteolytic lesions observed in man.

MATERIALS AND METHODS

Twenty-five Wistar male albino rats, of average weight 150 gr., were exposed to vapours of vinyl chloride 4 hours a day for 5 days a week during 12 months. The animals were kept in a plastic air-tight container through which there was a constant flow of air containing 3% in weight, equal to 30,000 p.p.m. of vinyl chloride. At the end of treatment the surviving animals were killed at twenty-day intervals, and the paws, brain, liver, kidneys and thyroid were examined histologically after fixation, inclusion and colouration by the ematoxylin-eosine. Van Gieson, PAS, Weighert, Bielschowsky-Gomori methods. Twenty five rats of the same breed were set aside as a control.

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RESULTS

During the period of exposure the animals were slightly soporific, but the first few months of treatment were well tolerated and the rats showed no change in body growth or behaviour and no organic alteration visible macroscopically or by radiological means. After ten months some of the animals began to show a decrease in weight, in agressiveness, in their reaction to external stimuli, and often a disturbed equilibrium. Thirteen animals died from cardio-respiratory complications. Two animals died from hemato-peritoneum. Most of the animals showed pathological involvement

of the brain, liver, kidneys, and thyroid. Six rats showed histopathological alterations of the skeleton.

The small metatarsal bones showed an extensive periostal proliferation of cartilage-like material apparently originating by metaplasia directly from the bone. All around the newly formed cartilage the cellular components were compressed and arranged tangentially to the cartilage itself, forming a perichondral layer. The isogenous cartilagenous groups were irregularly arranged and their nuclei were of varying size and often number per cell. The edges of the cartilage were irregular, showing digital extroflexions resulting from a varying growth potential. There was also evidence of chondroid metaplasia in areas of mature compact bone, in which the cartilagineous elements were grouped around a central nucleus of bone, as in typical osteochondromatosic processes. In the small bones the chondroid metaplasia was often very extensive and the bones seemed to be impregnated with a mucoid substande which altered the characteristic disposition of the bone tissue obliterating the cement lines. The skin of the paws showed areas of hyperkeratosis superficial thickening of the epidermis, vacuolization and degeneration of the basal layer, disappearance of the cutaneous adnexa and modest accentuation of the papillar layer of the derma. An almost constant state of edema was observed in the epidermic zone. The connective tissue showed dissociation of the collagen bundles and a diminution and fragmentation of the elastic reticulum. The small arterial vessels showed signs of endothelial fibrosis with a thickening and dissociation of the elastic membrane, often accompanied by a partial hyaline degeneration and homogenization of the walls and proliferation of the endothelium. Some of the vessels appeared completely blocked by a proliferation of the connective tissue in a formation not unlike that of onion skin.

The small nerve bundles were often surrounded and invaded by fibrotic processes. A microscopic examination of the brain revealed diffuse degenerative lesions of the grey and white matter. The external granular layer was often reduced and in some areas this was true also the medium sized and giant cells. Numerous xamples were found of hypercoloured, atrophic neurons with disappearance of the nucleoli and sometimes also of the nucleus itself. At the level of the white matter there were zones of intense, reactive gliosis consisting for the most part of cytoplasmic and fibrillar astrocytes, some of which were arranged in a concentric disposition around the blood vessels. There was evidence of neuronal phagokaryosis with satellitosis and the deposition of neuroglial elements around the altered nerve cells.

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There was modest proliferation of microglial elements, especially in areas of more intense gliosis and zones of intense spongiosis showing an accumulation of astrocyte-type elements with basophilic cytoplasm and abounding in gemistocytic and microglial elements similar in appearance to "scavenger" cells. The cerebellum showed signs of atrophy of the granular layer which was often represented only by a few isolated nuclei. The layer of Purkinje cells was in some places profoundly modified, the cells appearing to be undergoing intense degeneration and all the various stages of this process were observed, from the whole cell to the small homogeneous bodies with indistinct outlines which represent the most damaged form of the cell. Except for small and limited areas, the molecular layer seemed to be well preserved.

The liver was often of increased volume, sometimes subicteric in colour, with a smooth surface and somewhat more brittle consistency than normal. A histological examination showed in the majority of cases signs of diffused interstitial hepatitis with numerous hepatic cells in the grip of regressive processes varying from torbid degeneration of the cytoplasm to necrosis with marked cytoplasmic and nuclear polymorphism. Some of the hepatocytes showed giant or double nuclei. In these areas of cellular necrosis a corpuscolar exudation was always present consisting of round cellular elements of the lymphocyte or plasmacellular type. There was evidence of an abnormal proliferation of the Kupffer's cells, which were often hypertrophic. The triangular spaces appeared to be increased by the infiltration of round and polynucleated cells and eosinophiles showing marked polymorphism. The portal capillaries, centrolobular veins and sinusoids were often blocked by numerous centrally-located areas of partial necrosis, often accompanied by a diffuse steatosis in the form of small drops with clearly-defined areas of acidophile necrosis and the formation of elements similar to the round acidophile bodies of viral hepatitis and the "Cauncilman" bodies of yellow fever. In certain cases evidence was found of an intense fibrosclerotic reaction alongside the degenerative processes.

The kidneys did not appear to be excessively altered by the prolonged treatment with vinyl chloride, although they showed signs of tubulonephrosis, sometimes accompanied by chronic interstitial nephritis.

The thyroid often showed a colloid goitre and a marked increase in parafollicular cells.

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The control animals showed no histopathological alterations of the skeleton or of the various organs.

CONCLUSIONS

This research confirms that the animals are sensitive to the toxic action of vinyl chloride. The lesions of the bone and connective tissue are similar to those noticed in experimental osteo-latyrism and to those described in a man affected with acroosteolysis of the hands (Marin). It should be pointed out that the roentgenological findings of skeleton in man rests on cartilaginous transformation of the bone tissue. Therefore according to reccomendation made at XVI International Congress on Occupational Health of Tokyo (1969) I should like some precautions to be taken in the manufacturing plants polymerizing vinyl chloride, such as reduction of the threshold limit value of monomer, and substitution of manual cleaning of autoclaves by automatic devices.

SUMMARY

The results of this investigation show that animals exposed to vapours of vinyl chloride may show degeneration of the skeleton and connective tissue with histopathological pictures similar to those observed in human acroosteolysis of the hands. The bones in fact undergo processes of intense periostium growth and diffuse, chondroid metaplasis. The connective tissue is dissociated into collagen bundles with a reduced number of cells, the elastic reticulum is markedly reduced and fragmentary, the small vessels of the deep layers of the derma show hypertrophy of the walls with a diminution and sometimes obliteration of the lumen, the nerve endings are surrounded and infiltrated by fibrous tissue. Degenerative processes of the parenchyma were observed in the brain, in the liver and in the kidneys.

NOTE: Figures on available copy were not suitable for reproduction. They are as follows:

Fig. 1 -- Periostal proliferation of metatarsal bone of a rat 16th months old, exposed to vinyl chloride vapours for 12 months

Fig. 2 -- Periostal proliferation of metatarsal bone of a rat, 16th months old, exposed to vinyl chloride vapours for for 12 months

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Fig. 3 -- Periostal proliferation of metatarsal bone of a rat, 16th months old, exposed to vinyl chloride vapours for 12 months.

Fig. 4 -- Chondroid metaplasia in mature bone of metatarsus of a rat, 16th months old, exposed to vinyl chloride vapours for 12 months

Fig. 5 -- Chondroid metaplasia in mature bone of metatarsus of a rat, 16th months old, exposed to vinyl chloride vapours for 12 months

Fig. 6 -- Chondroid metaplasia in mature bone of metatarsus of a rat, 16th months old, exposed to vinyl chloride vapours for 12 months