BIO-MEDICAL RESEARCH
DOCUMENT DESCRIPTION FORM

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Source (Journal, Vol., Number, Pages, Date)

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RHEOGRAPHIC OBSERVATIONS ON WORKERS IN THE PLASTICS INDUSTRY

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TRANSLATION OF:

"Osservazioni reografiche in lavoratori dell'industria di materie plastiche," Securitas, Vol. 55, pp. 683-94, 1970.

Securitas, 55: 683-94, 1970

RHEOGRAPHIC OBSERVATIONS ON WORKERS IN THE PLASTICS INDUSTRY

G. Nitti, V. Petruzzellis and V. Fasano*

The widespread production and use of synthetic resins has given the impetus to some studies on unknown occupational risks, and to studying the disease symptoms and related work hygiene problems.

In particular, Rex H. Wilson et al [9] and Chatelain and Motillon [4] found, among workers in the plastics industry, especially those engaged in cleaning the polymerization autoclaves of monomer vinyl chloride (MVC), a typical syndrome: acroosteolysis of the fingers.

Guided by the above publication, we conducted an investigation of workers in a polyvinyl chloride factory with the object of contributing to knowledge of the clinical picture, to etiopathogenic interpretation of the disturbances, and their prevention.

TECHNOLOGICAL NOTES

The basic raw materials used in PVC production are:

1. methane
2. rock salt
3. air.

The production cycle for polyvinyl resins, in closed processes, includes various plants:

1. Air fractioning plant, which furnishes oxygen;
2. Acetylene plant, where the acetylene is obtained by partial combustion of methane with oxygen;
3. HCl plant, where the HCl is obtained by synthesizing hydrogen and Cl from electrolysis of rock salt in solution;
4. Monomer vinyl chloride plant, whore the acetylene and HCl react when special catalyzers are added and form MVC;
5. Polymerization plant. The MVC is polymerized in the presence of particular chemicals such that PVC in suspension and emulsion is obtained. Finally, the polyvinyl resin is washed, dried, and sold in the form of white powder.

Polymerization is done in special autoclaves with about 14 m^3 capacity. They contain a metal-blade agitator driven from the outside.

The polymerization autoclaves are cleaned periodically, as a hard resin scale forms on the walls, the blades of the agitator, and the inlets. This scale is removed manually by means of hammers, chisels, and scrapers, and not

* This article is the contribution of all three authors in equal parts.

infrequently with the hands directly. The autoclave is cleaned by two workers in an eight-hour shift: one of them works inside the autoclave and the other i outside, near the inlet aperture.

Before work begins, the polymer vapors are removed by blowing air into the autoclave. The operation is improved if performed when examination of an autoclave air sample shows the presence of 19% oxygen.

The hammer and chisel used by the workers weigh about 1 kg each.

MATERIALS AND METHOD

We observed 20 subjects employed in cleaning polymerization autoclaves.

The subjects had an average age of 33 (from 23 to 41) and had worked for an average of 21 months (from 3 months to 3 years)

With the exception of a single subject, who had previously been a drill operator in a metallurgical and mechanical factory, none of the subjects examined had previously worked on jobs with risk of disease to the peripheral vascular system or the bones (use of vibrating instruments, exposure to toxic products, etc.).

The operators were examined medically as out-patients. The examination included chest X-ray, hand X-ray, and laboratory tests: urine analysis, ESR, RA-test, azotemia, glycemia, calcemia, phosphoremia, and red blood count.

The patients also under went homodynamic tests on the upper limbs by th duo-rheographic method, using a Schuhfried apparatus coupled to a Schwarzer electrocardiograph. The rheographic traces in both limbs were reported under resting conditions, using the forearm segmentary longitudinal terminals, middle phalange pulse terminal, and middle interphalangeal terminal. As well as in resting conditions, the latter was also taken after cooling (by submerging the finger in crushed ice for five minutes) and after heating (submerging the finger in 40°C water for five minutes) 30 minutes apart.

RESULTS

Only two of the subjects had histories of hyperhydrosis, paresthesia and episodic ischemia of the fingers, and four subjects had previously complained of paresthesic symptoms in the fingers.

Objectively, no pathological signs were found for the various organs and instrument tests. The laborabory tests and instrument readings were normal, with the exception of calcemia, which in five subjects was slightly lower than normal.

X-rays of the hands showed: in one subject, a small erosion of the edge of the unguinal phalange of the fourth finger of the right hand; in another a small osteosclerosis of the unguinal phalange of the third finger of the right hand, and in another the presence of bone cysts of the second phalange of the second finger of the left hand.

The data from the rheographic examination, performed at the end of our investigation, deserves special mention.

After analysis of the case histories, we divided the traces into two groups: the first included 6 subjects in which rheographic examinations showed no morphological changes worthy of mention, and are thus considered normal; the second group included 14 subjects in which sharp variations of the traces, considered pathological, were noted and will be carefully described; this group included the 6 subjects with subjective complaints.

Analysis of the recordings showed modification of three types.

-- Type 1 (8 subjects).

Forearm Section and Pulse-Phalange Terminals (Figures 1a to 1b).

Bilateral reduction of pulse speed and amplitude. The apex of the wave appears chopped off with moderate undulation. Evident dicrotism.

Interphalangeal Terminal (Figure 1 c)

On the right hand, shape identical with the previous terminals, with truncated apex; on the left hand, the apex of the wave is pointed with evident polycrotic waves in the catacrotic phase;

After Heating (Figure 1d), increase in amplitude more obvious with left hand. The apex is rounded out and the dicrotism is accentuated;

After Cooling (Figure 1e), unequal pulse wave to the detrament of the right limb, where the apex is rounded.

-- Type 2 (6 subjects).

Forearm Section Terminal (Figure 2a).

Pulse speed and amplitude within normal limits. The catcrotic phase is made up of a series of waves with variable intensity and duration.

Pulse-Phalange Terminal (Figure 2b)

Same shape as above.

Interphalangeal Terminal (Figure 2c)

On the right, shape unchanged; on the left, tendency toward truncated apex;

After heating (Figure 2d)

Slight increase in amplitude with the same serrated appearance of the catacrotic phase;

After Cooling (Figure 2c)

Reduction of amplitude and accentuation of the catacrotic phase.

-- Type 3 (2 subjects)

Forearm section Terminal (Figure 3a)

Reduced pulse amplitude in both limbs, pulse speed markedly slowed down, "plateau" wave peak, sloping down gradually in the catacrotic stage, and composed of tiny irregular vibrations.

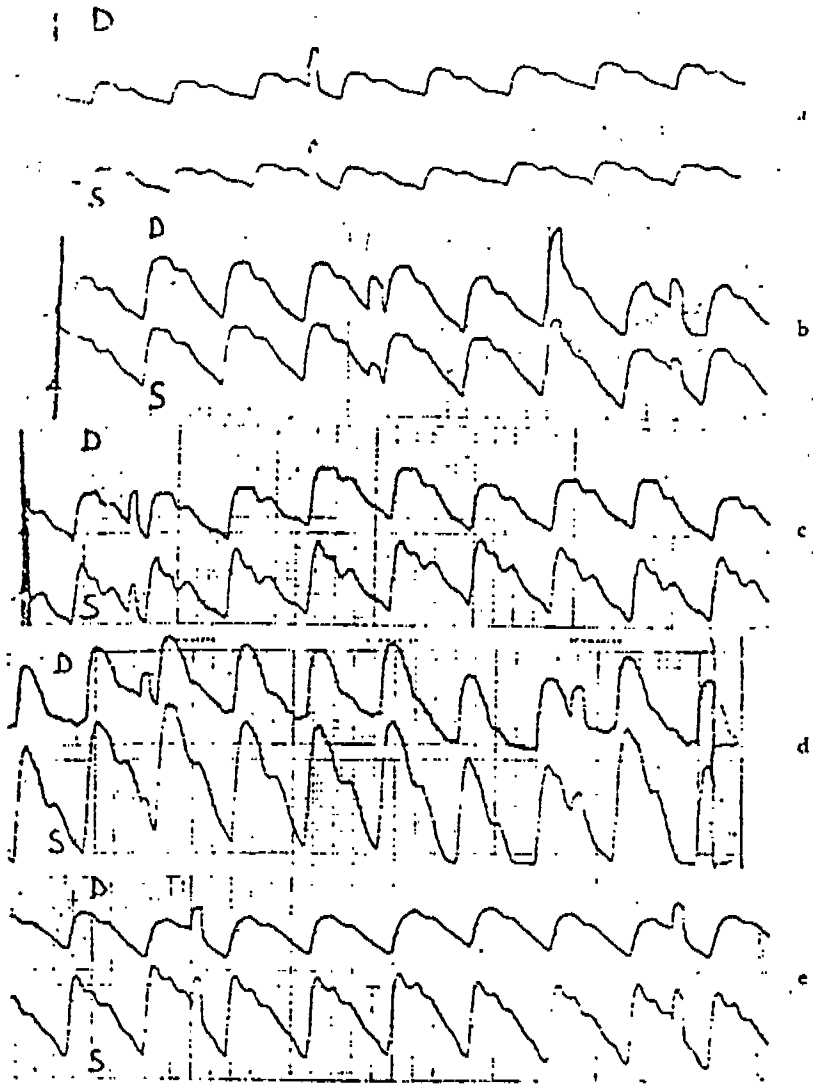

Figure 1. Forearm (a) and Pulse-Phalange (b) terminals under resting conditions. Intraphalangeal terminal under resting conditions (c), after heating (d) and after cooling (e).

D = Right hand, S = Left hand

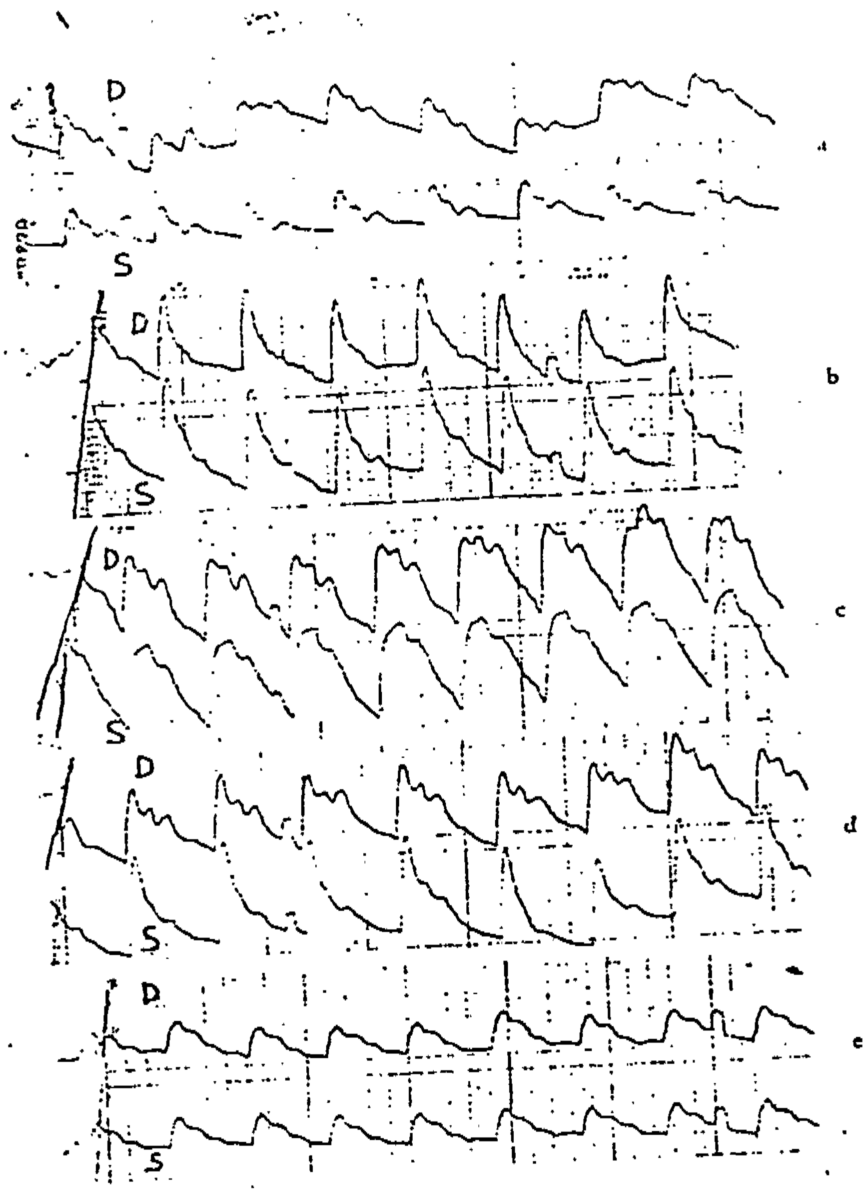

Figure 2. Forearm(a) and Pulse-Phalange (b) terminals under resting conditions. Intraphalangeal terminal under resting conditions (c), after heating (d) and after cooling (e).

D = Right hand, S = Left hand

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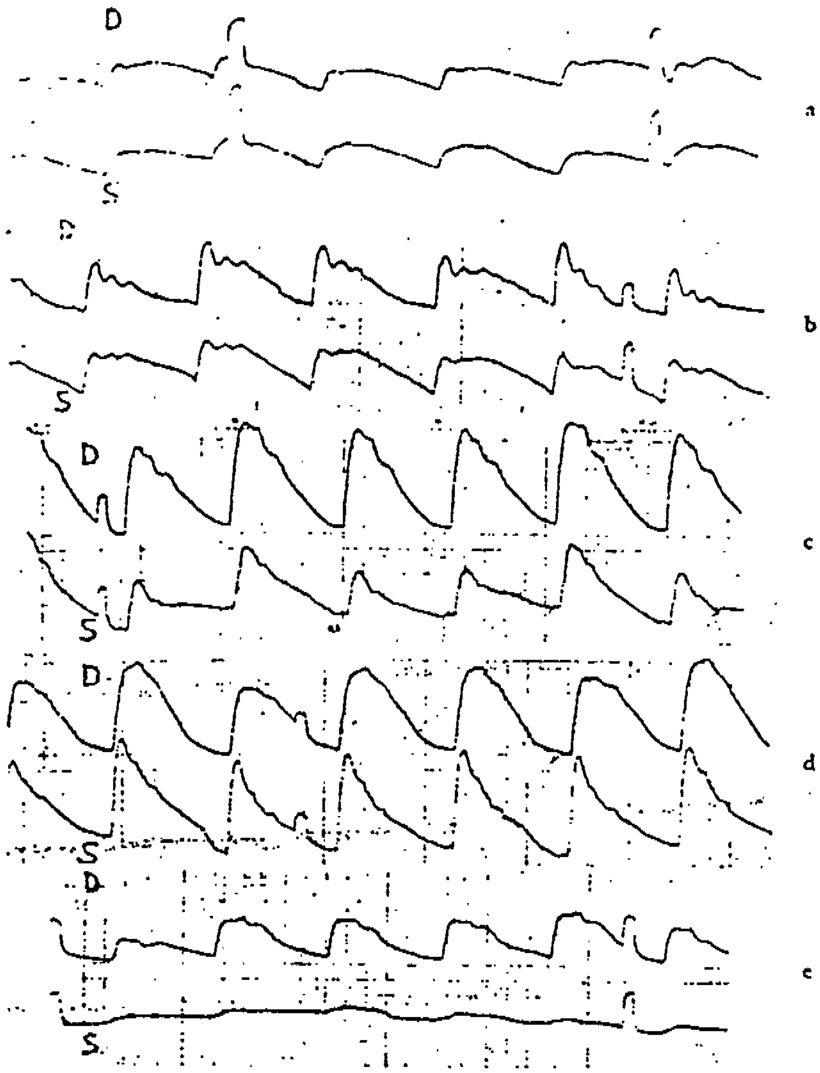

Figure 3. Forearm (a) and Pulse-Phalange (b) terminals under testing conditions. Intraphalangeal terminal under resting conditions (c), after heating (d) and after cooling (e).

D = Right hand, S = Left hand

Pulse-Phalange Terminal (Figure 3 b).

Slight uneveness of pulse especially in the left limb. Speed within normal limits. Obvious polycortic waves in the catacrotic phase.

Interphalangeal Terminal (Figure 3 c)

Clear uneveness of pulse especially in the left limb. The presence of small waves of different magnitude and duration persists in the catacrotic phase;

After heating (Figure 3 d)

While the right hand shows a roughly triangular wave, or a wave with a tendency to apical "plateau", on the left hand the shape is no different from that recorded under resting conditions, except for a slight increase in amplitude;

After cooling (Figure 3 e).

On the right hand, reduction in amplitude and accentuation of the truncated apex; on the left hand, considerable reduction in amplitude and speed such that the trace is almost a straight line.

DISCUSSION AND CONCLUSIONS

From the above, it appears evident that the data for the rheographic investigation are of some interest, while those from other examinations, except for the case history notes, show no significant pathological elements. In particular, we note that the X-ray findings for the fingers bore no relationship with the occupational risk; similar findings were reported by Chatelain and Motillon [4] although these did not include cases of acroosteolysis.

Some conclusions may be drawn from the rheographic investigations on the subjects examined. For 14 subjects out of 20, the behavior of the peripheral rheogram may be considered pathologic for various reasons. In the first place, the truncated appearance of the apex, the accentuated dicrotism, the presence of polycrotic vibrations of the catacrotic wave, are a constant feature of these traces, although of different intensity from subject to subject. The truncated apex is particularly evident in Group 1, while in Groups 2 and 3 the polycrotic vibrations and pointed appearance of the apex are outstanding. We would also emphasize the abnormal response to the heat tests. Finally, we noted an abnormal response to heat stimulation, although of various degrees from subject to subject. After immersing the finger in cold water the characteristic amplitude increase of the rheogram and dampening of dicrotism were not noted except in the patients of Group 1; on the contrary, in one or both limbs, the pointed apex and secondary undulations were observed to persist.

After cold stimulus, there was a more or less marked accentuation of the morphological features recorded under restings conditions, with attenuation of amplitude and speed which reached a high level for one limb only in two patients of Group 3.

Interpretation of these rheographic alterations, found in the majority of the subjects examined, allow us to affirm that the changed morphology of the apex, the pronounced dicrotism, the polycrotic vibrations of the wave descending phase, and the abnormal response to the heat test are valid grounds for hypothesizing the presence of manifest neurocirculatory dystonia with increased vasomotor tone of sympathetic imprint. This interpretation finds support in the literature on this subject (Bonanni [2], Califano [3], Garbini-Picchio [5], Marcialis-Giardino [8], etc.).

A pathogenetic interpretation of this neurocirculatory dystonia is anything but simple. In the first place, we must consider a possible constitutional deviation in neurovegetative tone in the sympathetic sense; this would explain why only some of the subjects exposed to the same occupational risk had signs of neurocirculatory dystonia. Although these irregularities of vascular motility are evident, we must still acknowledge the fact that other aspects of working activity may have more or less direct effects on the reticular orientation of the neurovegetative system, since the rheographic traces obtained from these workers are very different from those observed in constitutionally sympathetically tonic subjects (absence of appreciable modifications in pulse amplitude, pointed wave apex, high dicrotism, normal response to heat tests, etc.).

Together with the American and French authors [4-9], who reported the first cases of acroosteolysis, we believe that both mechanical and toxic factors may be involved.

With respect to the mechanical factor, it is known that workers using vibrating instruments can have peripheral vascular disturbances (Maggio, and Zazo [6], Barsi [1], Mangini [7]). Although workers who clean out autoclaves are not subject to marked vibrational stresses (as pneumatic hammers, drills, etc.) they are subject to mechanical stimulation by the percussion of the hammer and the chisel which, in its turn, strikes the metal wall of the autoclave, and these mechanical stimulations are associated with prolonged muscular contraction in holding on to the tools. They could thus be co-responsible in causing the altered local neurovascular function.

The toxic factor appears more difficult to assess; this difficulty is derived from an imprecise knowledge of the various catalyzers and stabilizers used in the MVC polymerization process, because disturbances in subjects handling finished PVC destined for manufacture into finished goods, and disturbances in subjects employed on raw materials for MVC production, are not the same type.

It should be noted that the pathogenic toxic substances are probably the catalyzer and stabilizer residues, and/or residues of intermediates used in the MVC polymerization process, which are probably still present in the polymer when emulsion or suspension, thus still in the scale on the autoclave walls.

The toxic probably first has a stimulating effect on vascular sympathetic tone, causing an alteration in local vascular reactivity; this would impair the blood supply leading to histochemical alteration in the tissues. No such alterations were found in our investigation, probably because the subjects examined for occupational risks were exposed only for a short time: in fact, the majority of them had been employed on this activity for a little more than a year, while only some subjects had been so employed for over three years.

Of particular importance is the small degree of clinical symptomotology found by contrast with the high percentage of rheographic alterations observed. It may be hypothesized that the particularly precocious peripheral hemodynamic alterations could represent a necessary pathogenic starting point for dissolution of the bones of the unguinal phalanges described by the above mentioned authors.

From these brief considerations emerges the importance of conducting more research on the causes and etiological mechanisms responsible for the symptoms described, in an attempt to clarify the object (toxic, mechanical, constitutional, etc. factors) of efficacious primary prevention.

However, we believe that, from the technical and medical prevention angle, suitable measures must be put in hand to safeguard the health of workers in this field (forced-air ventilation, personal means of protection, periodic medical examinations, etc.) not excluding systemmatic rheograms of the upper limbs in order to point up the initial signs of vasculopathy and implement the necessary health measures.

SUMMARY

On the basis of previous observations of acroosteolytic lesions in workers cleaning the autoclaves used for polymerization of monomer vinyl chloride, the authors subjected 20 persons doing the same job to blood chemistry, rheographic, and radiographic examinations of the upper limbs.

The experiment, while not confirming the presence of acroosteolytis, probably due to the short period of exposure to the occupational risk, did demonstrate in the majority of the cases examined (14 out of 20) the existence of sympathetic neurocirculatory dystonia. The authors consider that this functional disturbance is attributable to a mechanical and/or chemical factor of as yet unidentified nature, as a pathogenetic co-factor in the causation of osteolysis.

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