Rapid screening for peripheral neuropathy: A field study with the Optacon

Article abstract—The modified Optacon, a simple battery-powered device that measures fingertip vibration sensation, was used by paraprofessionals to screen 257 acrylamide-exposed individuals. Consistent data were obtained on repeated testing of individuals, and there was an age-related linear decrease in vibration sensitivity within the population. Subclinical peripheral neuropathy was detected in two individuals, one acrylamide-related and the other nutritional-alcoholic. This study establishes the use of the modified Optacon as a screening device for some types of peripheral nerve dysfunction.

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Early detection of peripheral neuropathy is a paramount concern for persons repeatedly exposed to exogenous neurotoxins or those who have metabolic disorders such as diabetes or uremia. A technique that assesses tactile and vibration thresholds from distal-most limb points would assist in early detection, because many toxic and metabolic neuropathies are heralded by distal symmetric sensory dysfunction.[1-4] Such high vulnerability of vibration sense in early acrylamide neuropathy may reflect the exquisite vulnerability of pacinian corpuscles and distal axons in the gracile fasciculus to this chemical.[5,6] The modified Optacon, a portable and readily available electronic device, enables paraprofessionals repeatedly to screen vulnerable individuals for peripheral neuropathy in the clinic.[7] We describe an 18-month field trial of the modified Optacon in evaluating workers from two chemical plants manufacturing acrylamide monomer.

Methods and subjects. A total of 257 workers were tested on two or more occasions, using the Optacon. (Since the completion of this study, Telesensory Systems, Palo Alto, CA, has introduced a variation of the Optacon, Optacon Tactile Tester (OTT). The OTT is wholly contained and designed to facilitate sensory testing.) Subjects ranged in age from 19 to 65 years and were divided between two diversified chemical plants (A and B). The age distribution of workers at the two plants was similar, with a mean age of 36.9 years at plant A and 36.1 at plant B. All tested subjects worked in the acrylamide facility of each plant, where work environments are carefully controlled and in compliance with the standards of the American Congress of Government and Industrial Hygienists.

Apparatus. The Optacon tactile stimulator is a portable, battery-powered unit. It was originally designed for use in concert with a camera module to enable blind individuals to read independently of Braille.[8] The stimulator consists of 144 miniature rods organized into a 24 × 6 matrix, with a 2-mm horizontal and a 1-mm vertical interrod spacing. Each rod protrudes through a contoured plastic plate and contacts a discrete portion of the skin. The rods vibrate continuously at 230 Hz; the height the rods extend above the plate and the amplitude of vibration vary as a function of voltage.

Procedure. Testing was done at each plant by local nurses trained by J.C.A. Absolute thresholds for the detection of vibration of the entire matrix were determined, using the ascending and descending method of limits.[9] The left index finger was positioned within the Optacon so that approximately 1.5 square centimeters of the ventral surface of the finger pad contacted the vibrating surface. Before testing, subjects were given a period of suprathreshold stimulation to familiarize them with the stimulus characteristics. Five ascending and five descending series were used to determine a single threshold. The highest and lowest scores of the 10 trials were removed before averaging. During testing, the subjects wore radio earphones with a continuous white noise; this reduced the ambient sounds and masked the voltage-dependent noise from the Optacon. Timing of ascending and descending trials was varied to avoid temporal cues, and subjects were prevented from seeing the intensity knob or voltmeter. In approximately one-fifth of the trials per subject, a "sham" series was run, during which a stimulus was not delivered. Thresholds were determined in a testing period of less than 5 minutes. Repeat tests were administered at 3- or 1-month intervals.

Results. *Population data.* The mean threshold score of the entire population of tested workers at plant A, averaged across age groups, is 4.33 V. The equivalent score at plant B is 4.15 V. The standard deviations of the data at A and B are 1.07 and 1.12 V, respectively. The means and standard deviations of the data at each facility do not significantly differ at the 0.05 level from the normal population.[7] The table represents a summary of the data for each group. The population data at both plants were remarkably consistent for each quartile investigated.

At both facilities, increasing age closely correlates with an increase in threshold voltage. This

Table. Means and standard deviations for the entire population of tested individuals at two chemical plants and a control normal population

	Plant A	Plant B	Nonchemical workers
$\bar{X}$	4.33	4.15	4.54
S D	1.07	1.12	1.09
N	132	125	100

The data for the nonchemical workers were obtained in a previous study.[7]

age-related decrease in vibration sensitivity is approximately linear and exists across the entire age range examined (figure). There is a concurrent increase in variability of threshold scores for older subjects when these are calculated separately for each decade.

To determine whether any job classification is at greater risk, data were grouped into four job categories: (1) assistant operator, (2) operator, (3) checker clerk, and (4) supervisor. It was not feasible to compare mean scores directly across groups because of an uneven age distribution (eg, assistant operators are generally younger than supervisors). To compensate, each individual was scored as above or below the mean for the appropriate decade value of the entire population. Job categories were subsequently evaluated to determine numbers of above- or below-average individuals. There are no significant differences in job categories at the 0.05 level.

Between 8 and 10% of all subjects tested were initially classified as having an elevated sensory threshold. This classification was based on one of the following criteria: (1) an elevation in the subjects' scores with reference to the pool of age-matched co-workers and controls, (2) a high degree of trial-to-trial variability in the ascending and descending series or, (3) a substantial change in threshold compared with previous scores for that individual. All subjects classified as "elevated" were retested at 1-month intervals for three successive test periods. During retesting, the index finger of the opposite hand was also assessed, and relevant medical and environmental factors were evaluated. After retesting, approximately 3% of the subjects (eight individuals) had persistent elevated or variable thresholds. This small group was screened by the local medical personnel for additional signs of neural dysfunction.

Case reports. Two asymptomatic individuals, one 43 and one 38 years old, displayed a pattern of scores on the Optacon and a preliminary clinical profile, determined by plant physicians, that indicated further evaluation at the Neurotoxicology Clinical Center at the Albert Einstein College of Medicine by H.H.S. At this evaluation, each displayed signs of distal symmetric sensory polyneuropathy: absent ankle tendon reflexes, severely diminished vibration sensitivity (measured with a 128-cps tuning fork) in all limbs, and moderately diminished touch, pin, and cold sensation in a symmetric stocking-and-glove distribution.

The 38-year-old man is a poorly nourished, chronic alcoholic subject who has minimal occupational exposure to acrylamide. He has physical and laboratory evidence of liver dysfunction, normal skin, and slowed sural nerve conduction. Subclinical peripheral neuropathy in this individual is most likely due to a combination of alcohol abuse or poor nutrition. The 43-year-old subject appears in good health and has experienced no weight loss. His general physical examination was unremarkable save for normal-colored but excessively smooth and slick palms and finger pads. This dermal alteration is a characteristic finding in individuals who have experienced previous heavy skin exposure to acrylamide monomer. Extensive laboratory evaluation, family history, and a review of nutritional status revealed no endogenous cause for neuropathy. Motor and sensory nerve conduction velocities and visual evoked responses were normal. This subject is currently a supervisor with little direct contact with acrylamide, but 2 years previously he had had continuous direct exposure to acrylamide, including handling the monomer. Subclinical sensory neuropathy in this individual most likely stems from his past acrylamide exposure.

After neurologic evaluation, both workers were counseled about avoiding future exposure to acrylamide monomer and repositioned within the plants to ensure against this possibility. The remaining six subjects with abnormal thresholds have to date displayed no clinical symptoms. These six individuals are considered "at risk" for neuropathy, and are being frequently monitored with the Optacon and periodically examined by plant medical staff.

As a validity check for the sensitivity of the Optacon in detecting acrylamide polyneuropathy, we tested an additional five individuals who had sustained past significant exposure to acrylamide monomer as municipal sewer workers (grouters) or in manufacturing facilities. Each had experienced dermal changes and characteristic neurologic signs that ranged from subtle sensory impairment to severe ataxia. Optacon scores in excess of 2 SD units above the age-matched control were recorded from each individual. The mean score for this group is 8.74 V. Two of these subjects have been repeatedly tested over a 1-year period, and their threshold scores remain consistently elevated for each quartile investigated.

Discussion. Acrylamide neurotoxicity, as the principal cause of neural dysfunction, was evident in only 1 of the 257 potentially vulnerable individuals tested. It is almost certain that at this time none exists in the remaining workers at these facilities, since in our experience the Optacon and other vibratory testing devices have proved extremely sensitive in detecting acrylamide neuropathy. Three percent of the tested subjects have

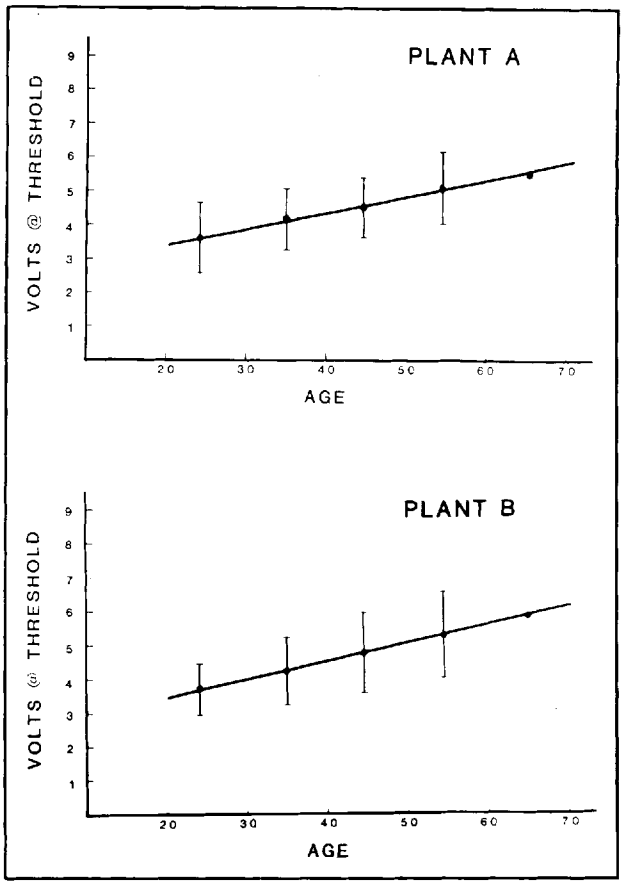

Figure. The means and standard deviations of chemical workers calculated separately for each age decade at each plant. Note the steady and linear decrease in sensitivity as a function of age. Voltage at threshold is plotted on the ordinate, because this represents a reliable and simple measure correlated with vibration intensity that can be determined under field condition. Standard deviations are not plotted for the 60 to 69 group because of the limited number of scores in this set.

elevated sensory thresholds and may have asymptomatic neuropathy. This figure is consistent with estimates of the prevalence of neuropathy in the general population within the examined age range.

Our study establishes that the modified Optacon enables paraprofessionals to screen individuals repeatedly for peripheral nerve dysfunction in the field. Consistent longitudinal data can be collected rapidly irrespective of the subject's age, and the procedure causes no discomfort to the subject. Individuals with elevated thresholds are readily identified, removed from their working environment, and given detailed neurologic evaluation. Thus, the Optacon appears most ideally suited for longitudinally monitoring workers with potential exposure to certain neurotoxins. In addition, it may prove useful in preemployment screening to detect individuals with subclinical sensory dysfunction associated with conditions such as diabetes, uremia, and neurotoxic pharmaceutical agents. Such individuals may be especially vulnerable to certain peripheral neurotoxins and should be advised to avoid occupational exposure to these agents.

The modified Optacon may also be of value in repeated field screening of certain other large vulnerable populations, eg: (1) individuals in oncology clinics receiving neurotoxic medications associated with sensory dysfunction such as vincristine, cisplatinum, and adriamycin, (2) patients in clinical trials designed to evaluate medication or therapy for diabetic or other metabolic neuropathies, and (3) as part of a battery of testing procedures in previously unstudied groups who are exposed to certain potential neurotoxins (industrial accidents or chemical disposal sites). Future clinical experience with this instrument may identify other conditions that it can readily detect. Clearly, there are neurotoxic situations where it would be of little value; eg, an individual exposed to trichloroethylene would experience disabling cranial neuropathy,[10] but probably display normal Optacon scores. Furthermore, there are peripheral neuropathies, eg, Guillain-Barré and type II hereditary motor and sensory neuropathy, that are primarily motor and, in our experience, have not been consistently associated with elevated Optacon sensory thresholds.

Finally, although the Optacon is most useful for rapidly surveying large populations for sensory loss, it is clearly not as sensitive as the elaborate computer-assisted devices currently employed in some centers to detect dysfunction of specific sensory systems,[11,12] and due to intersubject variability is no substitute for a careful examination by a neurologist.[13] It is probably best used, as in the present study, as a first-stage screening test in longitudinal studies to select a small number of possibly affected individuals for further careful evaluation.

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Acute myopathy associated with gasoline sniffing

Article abstract—Acute myopathy and myoglobinuria with markedly elevated creatine kinase (CK) activity developed in an 18-year-old boy on two occasions after gasoline sniffing. No signs of CNS involvement were seen, and the symptoms receded in a few days. The amount of lead in blood and urine exceeded the reference value for subjects with occupational exposure. The component of gasoline that was responsible for the myopathy remains unknown. Acute myoglobinuria appears to be a rare complication of gasoline sniffing.

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Gasoline sniffing is usually a habit of children and young adults from low socioeconomic background. It may cause acute or chronic encephalopathy[1] or peripheral neuropathy,[2] sometimes with fatal outcome. In two previous cases,[3,4] a concomitant muscle damage may have been present, although clinical signs of myopathy were not detected. We report a patient with severe recurrent myopathy and myoglobinuria after gasoline sniffing.

Case report. The patient was an 18-year-old boy with no professional training and no permanent dwelling. He had been working temporarily in various fields with no occupational exposure to organic solvents. His alcohol consumption was considered moderate, and he denied any use of narcotics. He had been sniffing gasoline vapors irregularly for a year. The usual amount was 1 to 1.5 liters at a time. During the past 6 months, he had experienced pain in the upper extremities lasting about 5 days after gasoline sniffing. On admission on June 26, 1980, he complained of aching pain in the muscles of the extremities and the back. Muscle strength was slightly reduced, and gait was difficult, mainly because of the pain. There was no sign of generalized infection, alcohol intoxication, or drug abuse. Slight dysarthria and ataxia may have been present on admission, but neurologic examination carried out 2 days later revealed no sign of CNS or peripheral nervous system involvement. The patient, however, complained of muscle pain and weakness, and he could not turn in bed or move his extremities in a normal way. The symptoms receded spontaneously in a few days, and he left the hospital on July 1 without permission. The results of the laboratory examinations are shown in the table.

He was rehospitalized on July 22, 1980, after a few days' history of worsening muscle pain in all extremities. He had sniffed about a liter of gasoline on July 15. He was again confined to bed for the first two hospital days because of muscle weakness and pain. Neurologic examination on July 24 was normal except for proximal muscle weakness in lower extremities and tenderness of calf and thigh muscles on palpation. EEG showed 6- to 8-Hz activity with an amplitude of 15 to 30 μV. EMG carried out on July 29 revealed potentials of low amplitude without fibrillations or signs of neuropathy. He was discharged asymptomatic on August 4, 1980.

In fall 1980, he was sentenced to prison for criminal activities. On control examination in May 1981, when still in prison, he was asymptomatic with normal neurologic examination. He denied having sniffed gasoline since summer 1980. EMG showed a few polyphasic potentials without other signs of myopathy. The EEG was