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## Studies of PCBs and Peripheral Neuropathy

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### Study #1

- numbness or neuralgic limbs associated with PCB poisoning
- mixed-type polyneuropathy
- lowered sensory nerve conduction velocity in radial or sural nerves, or both.

Some of the persons involved in an outbreak of "yusho" (polychlorinated biphenyl poisoning due to contaminated cooking oil) in Japan during the summer of 1968 complained of **numbness or neuralgic limbs**. Therefore, peripheral sensory nerve conduction velocity was measured in 21 such patients, and motor nerve conduction velocity in 19 of these. The motor nerve conduction velocity in the ulnar nerve was within the normal range in all of the patients; that in the tibial nerve was also normal, except in one patient with deep reflexes absent in all four limbs. In ten cases (48%), **the sensory nerve conduction velocity was lower than normal in the radial or the sural nerves or both**. In the group which displayed neuropathic symptoms in the lower limbs (about half of the total) six cases (75%) showed a slowing of conduction velocity in the sural nerve, whereas only one patient in the nonneuropathic group displayed reduced conduction velocity. These findings apparently represent early manifestations of a **mixed-type polyneuropathy**. (Murai et al, 1971)

### Study #2

- sensory and motor neuropathy occurs in patients with chronic PCB poisoning
- the higher the PCB concentration, the lower the nerve conduction velocity was of each nerve studied

The effect of polychlorinated biphenyls (PCB) and PCB derivatives on neuropathy was studied in humans. A group of 161 patients was exposed to daily ingestion of rice oil contaminated with PCB from September, 1978 to April, 1979. All patients developed eye and skin manifestations from March to June, 1979. Neurological evaluations and blood samples were taken from November, 1979 to April, 1980. A total of 110 patients who did not have elevated blood sugar or abnormal renal functions were compared with normal comparisons who were previously studied and did not have neurological diseases or did not have peripheral nerve disorder evidence or muscle disorders. The contaminated rice oil samples were tested for PCB and polychlorinated quaterphenyls (PCQ) by gas chromatography. The 100 patients blood tested for PCB. Blood samples were randomly taken for PCQ and polychlorinated dibenzofuran (PCDF) testing. The contaminated rice oil had 51.0 parts per million (ppm) PCB and 10.2ppm PCQ. The sensory nerve conduction velocity of the median nerve and ulnar nerve, approximately 52.0 and 48.0 meters per second (m/second), respectively, were **significantly lower** than comparison values. Motor nerve

conduction velocity of peroneal nerve and tibial nerve, approximately 49.1 and 45.8m/second, respectively, were **significantly lower** than comparison values. The PCB blood concentration of the patients ranged from 2.8 to 84.3 parts per billion (ppb) with a mean of approximately 39.3ppb. The PCQ and PCDF concentrations were approximately 8.6 and 0.076ppb, respectively. The higher the concentration of the intoxicating chemical, the lower the nerve conduction velocity was of each nerve studied. There was no significant difference in PCB concentration and patients with or without headaches. The authors conclude that **sensory and motor neuropathy occurs in patients with chronic PCB poisoning**. (Chen et al, 1985)

### Study #3

- peripheral neuropathy was associated with PCB poisoning at two sites
- synergistic/additive effect of PCBs with nerve growth factor, a protein required for the development and maintenance of ACh-containing neurones

Complex mixtures of polychlorinated biphenyls (PCBs) have been shown to be developmental neurotoxins in man and laboratory animals. Episodes of PCB poisoning have been reported, 1968 in Japan and 1979 in Taiwan, with clinical evidence of **peripheral neuropathy** in exposed people. The present study used whole embryo brain spheroid cultures, derived from hen and rat tissues, to study effects of exposure to the commercial PCB mixture, Aroclor 1254, on neural cell markers. Single cell suspensions were prepared from meninges free 7 day in ovo/stage 27-29 embryonic chick brains or 16 day old rat foetuses. Chick cells were cultured in serum-free media at a cell density of  $1.33 \times 10^6$  viable cells/mL. Rat cells were cultured at a density of  $1 \times 10^7$  viable cells/mL in DMEM with 10% fetal calf serum. Spheroid cultures were incubated at 37 degrees C/80 rpm in 5 and 9% CO<sub>2</sub> humidified air. Whole chick and rat brain spheroid cultures at 14 days in vitro (DIV) were exposed to Aroclor 1254 (2-60 uM) for 24 hours at 37 degrees C. Following exposure, homogenates were assayed for lactate dehydrogenase (LDH) release, glial fibrillary acidic protein (GFAP) and acetylcholinesterase (AChE) activity. All results except LDH, were normalised against total protein. Analysis of LDH leakage showed no significant difference over vehicle control (0.2% DMSO), indicating that Aroclor (2-60 uM) was not cytotoxic to the chick or rat brain spheroids. **GFAP levels (ug/mg total protein) were significantly increased** in rat brain spheroids treated with 60 uM Aroclor: control 0.3 +/- 0.1 vs. 0.5 +/- 0.1 Aroclor; there was no effect on GFAP levels in chick brain spheroids. AChE activity (IU/mg total protein) in chick and rat brain spheroids increased in the presence of Aroclor, with a significant (p less than 0.05) increase at 60 uM Aroclor: control chick 0.3 +/- 0.1 vs. Aroclor 1.5 +/- 0.5; control rat 0.9 +/- 0.3 vs. Aroclor 2.0 +/- 0.5. Results are mean +/- s.e.m., n = 4. The GFAP data reflects the traditionally higher levels of this glial protein in rat brain spheroids than chick brain spheroids. Aroclor (60 uM) induced a reactive gliosis in rat spheroids. However **AChE, a marker of neuronal toxicity, was significantly increased in both spheroid cultures indicating an effect of Aroclor on cholinergic neurones** in the rat and chick spheroids. This effect may be related to a **synergistic/additive effect of Aroclor with nerve growth factor, a protein required for the development and maintenance of ACh-containing neurones**. (Speight et al, 1998)

### Study #4

- PCBs produce toxic axonal neuropathy

Three types of toxic neuropathies corresponding to the principal component of peripheral nerves are outlined. Toxic distal axonopathy is the most common morphological reaction of the PNS to exogenous toxins. Of gradual onset, this disorder involves axonal degeneration in the central as well as the peripheral nervous system. Among agents that produce human **toxic axonal neuropathy** are drugs and environmental agents, such as acrylamide monomers, inorganic arsenic, organophosphates (TOCP, leptophos) and **PCB's**. (Schaumburg et al, 1979)

## Study #5

- PCBs resulted in peripheral sensory neuropathy in about two thirds of 2,000 poisoning cases, studied 2 years later
- PCB poisoning apparently affected not only sensory nerve conduction but also motor nerve conduction.
- no relationship between blood PCB concentration in patients with neurological manifestation and those without

Thirty-five patients out of the 2,000 PCB-poisoned cases that occurred in central Taiwan in 1978 were neurologically studied in 1980. Neurological manifestation included clinical **peripheral sensory neuropathy** in about two thirds of the cases, headache in two-fifths and dizziness in one-third. There **was no relationship between the blood PCB concentration in patients with neurological manifestation and those without**. Sensory nerve conduction velocity was reduced in about half of the cases and motor nerve conduction was delayed in about one-third of the cases, which suggested that **PCB poisoning apparently affected not only sensory nerve conduction but also motor nerve conduction**. Normal CSF PCB concentrations (0.5-2.3 ppb) indicated that PCB had difficulty penetrating the blood-brain barrier. A mildly abnormal EEG pattern was found in one fifth of twenty-seven cases. (Chia et al, 1984)

## Study #6

- peripheral sensory neuropathy was found in 54% of 28 PCB poisoning cases, studied 4 years later
- headache
- dizziness
- slower motor and sensory nerve conduction velocities

Neurological examination of 28 patients, 4 years after serious poisoning by polychlorinated biphenyl contaminated cooking oil, are compared with similar examinations of the same patients two years earlier (in 1980). **Clinical peripheral sensory neuropathy** was found in 54%, headache in 36% and dizziness in 46% of the patients; these findings did not differ ( $p$  greater than 0.1) from those in 1980. Although the mean blood polychlorinated biphenyl concentration (19.2 ppb) in the patients was lower ( $p$  less than 0.001) than that in 1980 (35.9 ppb), it was still higher than the normal value (less than 4 ppb). There was no difference in the blood polychlorinated biphenyl concentration of patients with neurological manifestation from those without. Although the mean motor and sensory nerve conduction velocities (MNCV and SNCV) were still slower ( $p$  less than 0.06) than the mean normal NCV, the mean MNCV of tibial nerve and SNCV of sural nerve were improved ( $p$  less than 0.06) as compared with those in 1980. EEGs (incomplete abstract) (Chia et al, 1985)

## Study #7

- peripheral neuropathy was found commonly in a large population of PCB poisoned people
- cognitive deficits in children (brain damage)

Cognitive deficits induced by prenatal exposure to polychlorinated biphenyl (PCB) contaminated cooking oil were studied. Approximately 2000 persons living in central Taiwan developed hyperpigmentation, acne, **peripheral neuropathy**, and other symptoms in 1979 following use of PCB contaminated cooking oil. The collection of symptoms was known as Yu-Cheng or oil disease. The cohort consisted of 115 children, 63 males, mean age 3.6 years, born to 69 women who had used the cooking oil for up to 9 months. The comparisons consisted of 115 children with no prenatal PCB exposure who were matched by age, sex, area of residence, and parental education and occupational class to the cohort. The comparisons also included 15 older siblings of exposed children. The

cognitive development of the children was evaluated annually until they were 7 years old using Chinese versions of the Stanford-Binet (SB) test and the Wechsler Intelligence Scale for Children (WISC). Four to 5 year old exposed children scored approximately 5 points lower on the SB test than did comparisons. Six to 7 year old exposed children consistently scored 5 points lower on the WISC than did comparisons. When the test data for the 4 and 5 year old exposed children were stratified according to year of birth, some evidence of a moderating effect of exposure was seen in children born longest after exposure. No significant cognitive deficits were seen in the siblings of exposed children. The authors conclude that children who are exposed prenatally to PCBs and related compounds have small but detectable cognitive deficits that persist up to 7 years of age. (Chen et al, 1992)

## Study #8

- peripheral neuropathy has been adopted as a standard symptom of PCB poisoning
- general malaise
- headache
- abdominal pain
- cough
- sputum
- soreness of joints
- deformity of nails
- comedo formation
- acne-like eruption, infection and scar formation
- disorder of Meibomian glands (tear ducts)
- edema of eye lids and increased discharge from the eyes

Results of Yusho annual inspection were reviewed from the view point of correlation of PCBs, PCQs and PCDFs concentration in blood or subcutaneous adipose tissue and clinical findings. To make discussion quantitative, fifteen terms of clinical findings on Yusho disease were quantified on the severity by evaluating (+) as 2 points, (+-) as 1 point and (-) as 0 point. First, the temporal variations of the severity of clinical findings on 5 Yusho patients were figured. Additionally, the temporal variations of blood triglyceride and PCBs concentration, and GOT were also surveyed. The **adopted terms of clinical findings** were general malaise, cough, sputum, headache, abdominal pain, **peripheral neuropathy**, soreness of joints, deformity of nails, comedo formation, acne-like eruption, secondary infection, scar formation, disorder of Meibomian glands, edema of eye lids and increased discharge from the eyes. During the investigated period from 1972 to 1988 the total score of clinical findings clearly decreased o (incomplete abstract) (Nakagawa et al, 1991)

## Study #9

- peripheral neuropathy was found in 17 firefighters exposed to PCBs, furans and dioxins
- abnormal current perception threshold measurements
- detoxification treatments reduced the effects

Seventeen symptomatic firefighters with a history of acute exposure to **polychlorinated biphenyls**, dibenzofurans, and dibenzodioxins were evaluated for **peripheral neuropathy** with the NeurometerR, a transcutaneous nerve stimulation device utilizing a constant current sine wave at fixed amperage for the evaluation of peripheral neuropathy. Prior to treatment with the Hubbard protocol (a method of detoxification utilizing niacin, aerobic exercise, sauna, and polyunsaturated oils for mobilization and excretion of fat-stored xenobiotics), five of the 17 had abnormal current perception threshold measurements. Following treatment, all showed improvement, with two studies returning to normal range. This data should further stimulate review of the neurotoxic effects of toxic

chemicals which have, heretofore, been thought to be irreversible. (Shields et al, 1989)

## Study #10

- peripheral neuropathy has been reported in people occupationally exposed to PCBs

Although their manufacture and use have been restricted or banned in Europe and the United States since the 1970s, polychlorinated biphenyls (PCBs) are still an ubiquitous environmental contaminant whose low-term effects are as yet not completely clear. Clinical case studies of patients with occupational exposure report cognitive impairment and **peripheral neuropathy**. In our defined nerve cell culture models in which we use pure neurons, pure glia and mixed cultures prepared from dorsal root ganglia of chick embryos we observed a neurotoxic effect after the application of a PCB compound (Clophen). It was only at higher concentrations that an additional gliatoxic effect could be observed. (Boegner et al, 1994)

## Study #11

- neuropsychiatric disorders including peripheral neuropathy and toxic neuropathy result from exposures to heavy metals, organic solvents, and organophosphates (several compounds related to PCBs)

This chapter outlined general principles for use in clinical monitoring as it relates to the task of the occupational physician to identify the actions of an occupationally related disease or condition active in a worker. Specific topics reviewed included: cardiovascular disease and the recognized occupational factors such as physical activity, exposure to carbon-disulfide (75150), dynamite manufacturing, solvents and aerosol propellants, stress and type-A behavior, hypertension and cardiomyopathy, the outcome of heart attacks, investigation of the hazard, and health monitoring; problems with the reproductive system including known and suspected occupational hazards such as exposure to heavy metals, polychlorinated biphenyls, pesticides, ionizing radiation, anesthetic gases, cytotoxic drugs, visual display units; occupational lung diseases caused by exposure to fibrogenic dusts, coal miners' pneumoconiosis, silicosis, asbestos (1332214) related diseases, man made fibers, occupational asthma, health monitoring and investigation of a hazard, byssinosis, extrinsic allergic alveolitis, disorders associated with heating and cooling systems, cancer of the respiratory tract, and occupational bronchitis; liver disease resulting from exposure to chlorinated hydrocarbons or toxic gases; **neuropsychiatric disorders including peripheral neuropathy and toxic neuropathy resulting from exposures to heavy metals, organic solvents, and organophosphates**; toxic organic psychosis, parkinsonism, the investigation of neurological disease in the workplace; disorders of the kidney arising from exposure to heavy metals, arsine (7784421), and organic compounds; malignancies of the genitourinary tract; damage to the skin arising from exposure to physical agents, irritant dermatitis, immunological contact dermatitis, changes in pigmentation, oil folliculitis and acne, malignant disease, investigation and monitoring of skin disease; and disorders of the musculoskeletal system including back pain, bony changes, and repetitive strain injuries. (Baxter et al, 1991)

## Study #12

- peripheral neuropathies have been noted in several cases of poisoning with halogenated aromatic compounds (such as PCBs and dioxins)
- general malaise
- chloracne
- weight loss
- impaired liver function
- hepatic porphyria

The toxicity of the chlorinated aromatic compound 2,3,7,8-tetrachlorodibenzo-p-dioxin (1746016) (TCDD) and its analogs is reviewed. A number of clinical abnormalities have been reported in individuals exposed to various halogenated aromatic compounds. A widespread response observed in humans is chloracne; other symptoms include weight loss, impaired liver function, hepatic porphyria, general malaise, and **peripheral neuropathies**. TCDD is the most potent of the halogenated aromatic compounds, and it is not easily degraded either biologically or chemically. Other related compounds such as polychlorinated biphenyls are readily metabolized, and therefore are not as toxic as TCDD. Pharmacokinetic and biomechanical studies are important in estimating human health risks. The genotoxicity of TCDD and related compounds is discussed with reference to human cells in culture. Model cell culture systems used to study mechanisms of epidermal toxicity are summarized; the use of these studies in risk assessment of halogenated aromatic compounds is discussed. The authors conclude that monitoring the molecular and biochemical events underlying pathologic changes in the skin provides a useful risk assessment model for halogenated aromatic compounds. (Greenlee et al, 1985)

### Study #13

- dioxin was associated with significant sensory neuropathy (certain PCBs are dioxin-like)
- chloracne
- sexual impotence

The existence of a **peripheral neuropathy** after exposure to polychlorinated dioxins (PCDD) is still discussed, as studies concerning dioxin effects on the peripheral nervous system are rare and contradictory. Clinical and neurophysiological examinations (motor conduction velocity of the peroneal nerve, sensory conduction velocities of the sural and ulnar nerves) were made in 156 dioxin exposed workers (42 with, 114 without chloracne) from one pesticide producing plant. Because of known risk factors for peripheral neuropathy, 7 workers with and 28 without chloracne were excluded from further analysis. **RESULTS:** Workers with chloracne had a significantly higher exposure against PCDD as documented by back calculated lipid levels. They complained significantly more often of sexual impotence (28.6% compared to 5.8% of workers without chloracne,  $P < 0.001$ ), had **significantly more frequent clinical signs of a sensory neuropathy** (= abnormal sensory findings plus deep tendon refl (incomplete abstract) (Thomke et al, 1999)

### Study #14

- neuropathy due to accidental or occupational PCB poisoning
- chloracne
- liver damage
- immunosuppression

Exposure to polychlorinated biphenyls (PCBs) was discussed. The physicochemical properties and commercial uses of PCBs and their congeners were summarized. The toxicological properties of PCB congeners were found to be influenced by the degree of chlorination and stereochemical structure. Due to their high heat and fire resistance, and low electrical conductivity, PCBs were typically used as mixtures rather than as individual congeners. PCB stability and lipophilicity were attributed to their persistence in the environment and accumulation in the food chain. Analytical methods for determining PCBs usually involved chromatographic separation and detection by electron capture or mass fragmentography. The toxicological properties of PCBs were discussed. The metabolism of PCBs was characterized by absorption via the gastrointestinal tract, skin, and respiratory system; wide body distribution; high accumulation in adipose tissue; and slow elimination, with typical biological half-lives in humans on the order of several years. Most information on human toxicity came from cases of accidental or occupational poisoning. Toxic effects included chloracne, liver damage, immunosuppression, and **neuropathy**. Experimental animal studies

have yielded similar effects as well as reproductive and developmental disorders and liver tumors. The chemical configurations of the various PCBs were discussed with reference to their toxicity. Biomarkers of PCB exposure included serum or plasma PCB, adipose tissue, cord blood, and breast milk PCB concentrations. Serum and adipose concentrations were the most widely used for assessing PCB exposures and risk. Cord blood concentrations have occasionally been used to monitor fetal exposure to PCBs. Breast milk PCB concentrations have been used as exposure markers for suckling infants. Possible associations between biomarkers and PCB toxicity were considered. Few reliable or definitive data have been obtained that defined relationships between biomarkers and PCB toxic effects. This has been attributed to the nature of the analytical methods used and possible confounding exposures. (Skerfving et al, 1994)

## Study #15

- neuropathy after occupational exposure to PCB commercial mixture Clophen-A-30
- areflexia of lower extremities (absence of the reflexes)
- atrophy of small foot muscles
- chronic neuropathy with pronounced decrease of thick myelinated nerve fibers
- anosmia (lack of smell)
- hyporeflexia (diminution or weakening of reflexes)
- scarce fibrillations
- cognitive dysfunction (brain damage)

Three patients who developed occupationally induced toxic **neuropathy** after exposure to Clophen-A-30 (55600345) while carrying out maintenance or disposal work on transformers and capacitors were described. Case-1 was an electrical engineer, age 69 years, who immersed his hands in transformer oil for at least an hour a day between 1960 to 1984. In 1982 he developed increasing numbness of the toes and feet and movement disorders. In 1990 neurological examination found areflexia of the lower extremities, atrophy of small foot muscles, and chronic neuropathy with pronounced decrease of thick myelinated nerve fibers. Case-2 was a mechanic, age 40 years, exposed to Clophen-A-30 between 1983 to 1988. Neurological examination showed anosmia, hyporeflexia, and cognitive dysfunction. Case-3 was a mechanic, age 32 years, who worked 5 years in the same workplace as Case-2. No clinical signs of neuropathy were apparent, but neurophysiological/psychological examinations found scarce fibrillations and cognitive dysfunction. These three cases of occupational polychlorinated biphenyl (PCB) exposure developed under very poor standards of occupational hygiene. The authors conclude that the unusual aspect of the cases is the remarkable persistence of clinical defects, which may be due to the long half life of PCB substances. (Altenkirch et al, 1996)

## Study #16

- sensory neuropathy due to occupational PCB exposure
- lassitude (fatigue)

The status of polychlorinated biphenyls (PCBs) was discussed in regard to their manufacture and industrial applications; disposal; presence in the environment; accumulation in the food chain, including their toxicity, metabolism, and embryotoxicity in nonhuman species; acute exposure in humans; occupational and chronic exposure in humans; and issues for the present and the future. An estimated 270 million kilograms of PCBs was estimated to have been buried in North American landfill dumps up until 1972. Traces of PCBs were demonstrated in virtually every living species and in every stretch of land and water examined. In general, adverse effects on mammalian reproduction tended not to be manifested until the food content, dosage, or tissue level of PCBs reached 10 parts per million or more. The two most serious outbreaks of acute human PCB poisoning occurred in Japan in

1968, with 22 deaths from ingestion of contaminated rice-oil, and in Taiwan in 1979, with 24 deaths from ingestion of contaminated rice-bran-oil. Clinical responses to occupational PCB exposure included chloracne, rashes, nail pigmentation and deformity, ocular burning and edema, pigmentation of the conjunctiva, immunological abnormalities, nausea, lassitude, anorexia, digestive disturbances, impotence, **sensory neuropathy**, hematuria, and hepatic involvement. The author concludes that effective PCB disposal facilities are vital if the destruction of existing stocks is to be achieved safely, and that continuing vigilance will remain a valuable guard against accidents in the form of unforeseen random exposure both to PCBs and to their toxic degradation products. (Jones, 1989)

## Study #17

- neuropathy symptoms of pain and numbness
- hypoesthesia (abnormally decreased sensitivity to stimuli, particularly to touch. Called also hypesthesia.)
- areflexia (absence of reflexes)
- altered nerve conduction velocity

The toxic effects of polychlorinated biphenyls (1336363) (PCB), polybrominated biphenyls (PBB), tetrachloro-dibenzo-p-dioxin (TCDD) (1746016) and chlordecone (143500) (CDC) were reviewed, with emphasis on their **toxic activity at the level of the nervous system**. PCB was found to induce an acniform eruption together with **neuropathy symptoms of pain, numbness, hypoesthesia, areflexia, and altered nerve conduction velocity** in humans. Experimental studies revealed the occurrence of neurobehavioral disorders in animals. A correlation was found between skin, neurological and musculoskeletal disorders in farmers exposed to PBB, while high levels of serum PBB were associated with neurobehavioral disorders in humans. Experimental studies in animals exposed to PBB also revealed the presence of neurobehavioral disorders. TCDD was associated with chloracne, hyperpigmentation, cold intolerance and neurological symptoms in humans. Polyneuritis, sensory impairment, psychopathological changes and a variety of neurological effects were identified in workers and populations exposed to CDC contaminated chemicals. An outbreak of nervousness and tremulousness was recorded among workers employed at a facility engaged in the manufacturing of CDC; instances of headache, increased cranial pressure and papilledema were also reported. CDC was found to induce tremors and exaggerated startle reflex in experimental animals. (O'Donoghue, 1985)

## Study #18

- decreased vibration sense in the lower limbs
- nerve conduction velocity showed 51.6% abnormal: sensory neuropathy in 44.5% and motor neuropathy in 23.9%
- headache/dizziness
- impaired memory/mental dullness
- acroparesthesia (an abnormal sensation, such as tingling, numbness, pins and needles, in the hands and fingers.)
- acrodynia (a disease of infancy and early childhood marked by pain and swelling in, and pink coloration of, the fingers and toes and by listlessness, irritability, failure to thrive, profuse perspiration, and sometimes scarlet coloration of the cheeks and tip of the nose. It is normally due to absorption of mercury. Called also erythroderma polyneuropathy and pink disease.)
- dysmetria (inability to properly direct or limit motions)
- impaired hearing

In 1979 a rare outbreak of polychlorinated biphenyl poisoning occurred in Taiwan. There were more than 2000 victims. Neurological studies were done with 155 persons. Neurological complaints were noted in 55.5%. These

consisted of headache/dizziness in 34.8%, impaired memory/mental dullness in 20.0%, acroparesthesia in 36.1% and acrodynia in 15.5%. Neurological examination revealed dysmetria in 1.9%, impaired hearing in 5.8% and decreased vibration sense in the lower limbs in 7.7%. Examination of **nerve conduction velocity showed 51.6% abnormal: sensory neuropathy in 44.5% and motor neuropathy in 23.9%**. A comparison was made between the Japanese Yusho and American occupational victims. (Chen et al, 1983)

## Study #19

- numbness of the extremities

A review of the data and a summary of findings regarding the potential human health hazards of polychlorinated biphenyls (PCBs), polychlorinated dibenzofurans (PCDFs), polychlorinated dibenzo-p-dioxins (PCDDs), and related compounds resulting from electrical equipment fires or failures were presented. Physical and chemical properties of PCBs, use of PCBs in electrical equipment, potential for exposure to PCBs and related compounds following fire or failure of electrical equipment, and exposure limits were presented as background data. **Toxic responses noted in PCB, PCDF, or PCDD treated animals are analogous, however, individual compound potencies vary with regard to the degree and position of chlorination.** A soot sample collected after a transformer fire in New York in 1981 yielded 5000 micrograms/gram (microg/g) PCBs, 48microg/g 2,3,7,8-tetrachlorodibenzofuran (51207319), and 1.2microg/g 2,3,7,8-tetrachlorodibenzo-p-dioxin (1746016). The median lethal dose (LD50) of the soot in aqueous methyl-cellulose, when administered in a single oral dose in guinea-pigs, was 410mg/kg; the LD50 of a benzene extract of the soot was 327mg/kg. Reported health effects in humans upon exposure to PCBs include chloracne, hyperpigmentation, gastrointestinal disturbances, elevated serum enzyme and triglyceride levels, and **numbness of the extremities**. As prudent public health policy, NIOSH recommends that occupational exposure to PCBs, PCDFs, and PCDDs resulting from electrical equipment fires or failures be controlled to the lowest feasible limit. Keeping occupational exposures as low as possible involves recognition of potential hazard, assessment of exposure, personal protective clothing, respiratory protection, decontamination and worker protection programs, post decontamination testing, and medical surveillance. (NIOSH, 1986)

## Study #20

- numbness of limbs
- fatigue
- headache
- dizziness
- abdominal pain
- expectoration (coughing up phlegm)

The relationship between the amount of polychlorinated-biphenyl (1336363) (PCB) ingested by Yusho (PCB contaminated oil poisoning) patients in contaminated rice oil and their subjective symptoms was studied. The amount of PCB consumed was determined by interviews with the housewives in families where Yusho occurred. Total individual rice oil consumption was estimated by taking into account age, sex, and number of meals at home. Forty six patients were analyzed in 1970 and 33 in 1971. A dose relationship was observed with the subjective symptoms that included numbness of limbs, coughing, expectoration, and the sensation of elevated teeth. High rates of general fatigue and eye discharge appeared to be closely connected with Yusho. Other symptoms, including fever, headache, dizziness, abdominal pain, joint swelling, menstrual changes, and loss of hair failed to show consistent dose response relationships; a causal relationship could not be ruled out, however. In a comparison of Yusho patients with healthy comparisons, fatigue, headache, dizziness, abdominal pain, **numbness of limbs**, and expectoration appeared to be related to Yusho. The authors conclude that further investigations from clinical and etiological

standpoints are needed in order to clarify the relationship between the subjective symptoms and Yusho. (Yoshimura et al, 1985)

## Study #21

- numbness in limbs
- transient visual disturbances
- feeling of weakness
- headaches

Human exposure to polychlorinated-biphenyls (1336363) (PCBs) as a result of consumption of contaminated species of fresh water fish was discussed. The twelve species of fish showing the highest PCB levels in parts per million included carp (1.10), catfish (1.70), Buffalo (0.50), fresh water trout (1.36), sea trout (0.56), bass (1.28), chubs (1.14), bluefish (0.53), porgy (0.72), drum (0.49), mackerel (0.53), and all others (0.26). Accidental human exposure to PCBs has occurred and typical symptoms include chloracne and increased pigmentation of the skin, increased eye discharge, transient visual disturbances, feeling of weakness, **numbness in limbs**, headaches, and disturbances in liver function. Children born to affected mothers had skin discoloration which eventually regressed, although symptoms occurring in adults were typically protracted in nature, suggesting slow metabolic elimination of contaminating PCBs. PCB contamination of both surface waters and bottom sediments occurs widely throughout the major drainage basins of the United States, including the South Atlantic Slope, the Eastern Gulf of Mexico, and the Great Lakes. Some reduction in human contamination resulting from the ingestion of PCB containing fish occurs due to trimming and cooking. PCB related reproductive disfunctions have been reported to occur in the rhesus monkey and in other species. The difficulties in establishing reliable estimations of risk prompted the authors to suggest either a 1 or 2 parts per million tolerance be set for permissible levels of PCB contaminating sport fish subject to human consumption. (Cordle et al, 1982)

## Study #22

- numbness in extremities

The correlation between blood PCB concentration and clinical manifestation of symptoms was investigated in 259 chronic "Yusho" patients, using the information obtained from the nationwide health examination conducted in 1988, twenty years after the outbreak. Concentrations of blood PCBs ranged 0.6-32.0 ppb (mean; 4.78), and they were categorized into approximate quartile for analysis. For general fatigue, odds ratios at 2.7+, 4.1+, and 6.1+ ppb were 2.4, 3.6, and 3.1, respectively, with a reference category of < 2.7 ppb (test for trend;  $p < 0.005$ ). **For numbness in extremities, the corresponding odds ratios were 2.8, 2.8, and 2.9 ( $p < 0.005$ ).** For comedone, they were 1.4, 1.0, and 4.0 on face ( $p < 0.025$ ); and 3.6, 4.6, and 9.5 on trunk ( $p < 0.005$ ), respectively. A distinctive increase in odds ratio was observed at 2.7 ppb for these two subjective symptoms; and at 6.1 ppb for skin symptoms. The blood PCB concentrations among patients were relatively close to the normal subjects. Therefore, (incomplete abstract) (Hirota et al, 1995)

## Study #23

- numbness in extremities
- general fatigue
- headache
- chronic bronchitis-like symptoms, such as cough and sputum

To investigate the frequency of symptoms and signs and their relationships with blood PCB (polychlorinated biphenyls) levels, twenty-five years after outbreak, we analyzed the data of 276 Yusho patients (male/female: 137/139) who had received health examination in 1993. For this purpose, 31 examination items which correspond or relate to the diagnostic criteria for Yusho (1976) were selected from the examination form. Mean blood PCB concentration in the subjects was 4.69 ppb with the highest value of 31.0 ppb (median : 4.0 ppb). The symptoms for which the proportion exceeded 60% were general fatigue, headache and **numbness in extremities**. Chronic bronchitis-like symptoms, such as cough and sputum, were observed in 50% of the subjects. Next, the subjects were classified into approximate quartiles of blood PCB: < 3.00, 3.00-4.06, 4.07-5.99, and 6.00+ppb. The distributions of subjects at four levels of blood PCBs were compared between the groups with or without each symptom or sign, using the Cochran- (incomplete abstract) (Hirota et al, 1997)

## Study #24

- numbness and tingling
- headaches
- unusual tiredness
- skin irritation, itching and redness
- pimples
- abdominal pain
- nausea
- dizziness
- headaches
- increased eye discharge

On June 22, 1982, the main power transformer at a private school in the midwestern United States became pressurized from internal arcing and vented approximately 50 gallons of askarel into the basement transformer vault. Areas of the building were contaminated. An oil sample contained 1.4 percent the polychlorinated-biphenyl (PCB) Aroclor-1260 (11096825), 33 percent trichlorobenzene (12002481), and 27 percent of a tetrachlorobenzene. Airborne PCB levels measured the day after the incident ranged from 50 to 90 microgram subic meter (microg/m<sup>3</sup>) inside the vault, 2 to 20microg/m<sup>3</sup> in areas near the vault suspected of being contaminated, and below the limit of detection (0.24microg/m<sup>3</sup>) in other areas. The concentration distribution was similar for chlorinated benzenes. PCB surface concentrations ranged from a maximum of 5000 micrograms/100 square centimeters inside the vault to a minimum of 0.05 microgram/100 square centimeters in other areas. Neither polychlorinated dibenzofurans nor polychlorinated dibenzo-p-dioxins were detected. Based on questionnaire responses, individuals were stratified with respect to amount of exposure. Twenty five were classified as moderately exposed, and 33, who did not enter the building, were lightly exposed. Some moderately exposed persons reported headaches, unusual tiredness, skin irritation and redness, pimples, abdominal pain, nausea, dizziness, and **numbness and tingling**. Some lightly exposed persons reported headaches, nausea, pimples, itching, unusual tiredness, and increased eye discharge during the first week after exposure. There were no significant differences in symptom prevalence between the moderately and lightly exposed groups. While serum PCB levels were less than 5 parts per billion (ppb) in 37 percent of the cases, they ranged up to 16ppb in one individual. Except for a consistent and expected fasting elevation of triglycerides, no uniform deviation from normal was detected in blood testing. Significant differences were not detected in mean blood chemistry or hematologic values between exposure groups. Although there were several significant differences in blood chemistries and other clinical testing, these were minor and were not suggestive of any significant toxicity from exposure. (Orris et al, 1986)

## Study #25

- numbness in the limbs

- visual disturbances
- weakness

The health effects of polychlorinated biphenyls (PCB) and polybrominated biphenyls (PBB) are reviewed. The chemical composition of the compounds is described, and oxidation and hydrolysis by light or other environmental agents is examined. The metabolism and biochemical toxicity of PCB and PBB are considered. Animal toxicity studies are cited in which depressed reproduction, hepatic porphyria, hepatomegaly, liver tumors, and effects on gastric mucosa and lymphatic systems have been seen. Cases of human exposures are assessed, and routes of exposure are considered. Typical clinical findings of human exposure to PCB include chloracne, increased pigmentation of the skin, eye discharge, visual disturbances, weakness, **numbness in the limbs**, and disturbances of liver function. Little is known about effects of PBB on humans. General recommendations include: complete metabolism studies for the individual compounds; toxicological studies by species and by route of administration; quantitative evaluations of human exposures with respect to content of PBB and PCB in blood and body fat; examination of occupationally exposed subjects; identification of chemical components of PCB residues; and analysis of contaminants present in commercial PCB and PBB mixtures. (U.S. Dept. of Health, Education, & Welfare, 1976)

## Study #26

- tingling and numbness in the extremities
- headache
- fatigue.
- mucous membrane irritation
- respiratory problems
- inability to concentrate
- thermal discomfort

The results of a health hazard evaluation at a school building were summarized. The evaluation was requested by teachers and the principal of a midwestern junior high school because of complaints of mucous membrane irritation, respiratory problems, **tingling and numbness in the extremities**, inability to concentrate, and thermal discomfort. The school had been converted from an open space classroom configuration to a conventional configuration by erecting walls between the classroom areas 6 years previously. The air handling system had been modified only by adding a false ceiling return plenum. The school had recently been treated for termite infestation with chlordane (57749), chlorpyrifos (2921882), and diazinon (733415). The fluorescent lighting system contained polychlorinated-biphenyl filled light ballasts. Elevated concentrations of carbon-dioxide (124389) and volatile organic compounds were found. Ventilation rates were below Diazinon and aroclor-1254 (11097691) were found in carpet samples at concentrations ranging up to 76 and 67 micrograms per gram, respectively. Chlordane, diazinon, chlorpyrifos, and aroclor-1254 were detected on dermal contact surfaces. Diazinon, chlorpyrifos, chlordane, and aroclor-1254 were detected in the classroom air at concentrations ranging up to 2.4, 0.60, 55.3, and 0.19 micrograms per cubic meter, respectively. After decontamination, and replacement of the ventilation system, measurements indicated significant improvements in indoor air quality. Only traces of aroclor-1254 could be detected. A symptom questionnaire administered to the employees after the renovations showed a 50% decrease in the prevalence of symptoms such as upper airway and mucous membrane irritation, headache, and fatigue. Analysis of blood samples from some employees showed chlordane metabolite concentrations similar to those of the general population. The author concludes that a potential health hazard from exposure to chlordane, chlorpyrifos, diazinon, and aroclor-1254 has existed at the school. (Tharr, 1991)

## Study #27

- neurophysiological impairments and cognitive and psychomotor dysfunction
- hand and foot numbness
- headache
- staggering
- dizziness and blurred vision
- abnormal heart beat
- breathlessness
- excessive sweating
- depression
- impaired or reduced choice reaction time, sway speed, blink reflex latency, performance on a psychomotor control test, recall, and long term memory
- prevalence of **lupus** and respiratory symptoms was significantly greater

Neurobehavioral abnormalities in persons exposed to groundwater contaminated with effluents from an aluminum die casting factory were studied. The cohort consisted of 117 African Americans (women and men), mean age 41.1 years, living near an aluminum die casting factory at Muscle Shoals, Alabama, who drew their drinking water from wells contaminated by effluents from the facility. They had complained of symptoms such as headache, **hand and foot numbness**, staggering, dizziness, blurred vision, abnormal heart beat, breathlessness, excessive sweating and depression. The well waters had been found to be contaminated with volatile organic compounds and polychlorinated biphenyls. The comparisons were 46 African Americans, mean age 39.0 years, who lived 30 kilometers from the factory. The subjects were interviewed by questionnaire to obtain information on occupational exposure to potential neurotoxicants. They were evaluated on a neurobehavioral test battery that examined simple and choice reaction times, body sway speed, blink reflex latency, color discrimination, nonverbal and nonarithmetic intelligence, recall, cognitive and psychomotor control, long term memory, and mood states. The prevalence of lupus symptoms and arthritis, respiratory disorders, and depression was determined. Approximately 69% of the cohort and 83% of the comparisons had been occupationally exposed to potential neurotoxicants. Choice reaction time, sway speed, blink reflex latency, performance on a psychomotor control test, recall, and long term memory were significantly impaired or reduced in the cohort. The **prevalence of lupus and respiratory symptoms was significantly greater** in the cohort than in the comparisons. Excluding occupationally exposed subjects from the analysis did not significantly alter any of the findings. The authors conclude that exposure to the contaminated water has led to neurophysiological impairments and cognitive and psychomotor dysfunction. (Kilburn et al, 1993)

## Study #28

- numbness and tingling of the extremities
- upper airway irritation
- eye irritation
- inability to concentrate
- comfort complaints of too hot and too cold

In response to a request submitted by teachers and the principal of the Andrew Jackson Junior High School (SIC-8211) in Cross Lanes, West Virginia, an evaluation was undertaken of possible hazardous conditions at the site. The symptoms experienced by the teachers included **numbness and tingling of the extremities**, upper airway irritation, eye irritation, inability to concentrate, and comfort complaints of too hot and too cold. The single story school building was constructed as an open space classroom configuration. It was heated, cooled and ventilated by nine individual roof mounted air handling units with ducted air supply. The false ceiling space served as the return air duct to the system. During 1981 to 1983 this open space was converted to approximately 30 classroom areas by erecting walls. The heating, ventilation, and air conditioning systems were modified only by adding a false ceiling return air plenum to accommodate the space conversion. The school had been treated for termite infestation by sub

slab injection of chlordane (57749) and direct in room application of chlorpyrifos (2921882) (Dursban) and Diazinon (333415). Fluorescent light ballast burn outs over several years introduced Aroclor-1254 (11097691) into the building which was not effectively removed by the ventilation system. Several class rooms also registered too high for carbon-dioxide (124389) concentration, temperature and humidity levels. Recommendations were made to reduce the exposure potential to chlordane and Aroclor-1254, improve the ventilation of the classrooms, and improve the indoor air quality of the school. (Elliott et al, 1991)

## Study #29

- nervous system can be poisoned causing symptoms such as headache, fatigue, irritability, palm sweating and numbness of the legs

Different types of acne can be produced by three different groups of chemicals. The first group contains petroleum, and its derivatives, particularly all compounds found in crude oils, and these cause oil acne. Blisters appear in areas where oil exposure is heavy. Areas of the body covered with oil soaked clothing may also develop oil acne. Persons with this condition should see a physician as the skin lesions can develop into skin cancer. The second group contains certain coal-tar (8007452) products which cause coal-tar acne. The oily substance and keratin form the black plugs that mark this condition. These are typically found around the eyes. The condition usually clears rapidly. This condition may result in skin cancer if not treated appropriately and promptly. The third group contains halogenated aromatic compounds such as

polychlorinated-biphenyls (1336363) which cause chloracne. The oily substance and keratin form yellow cysts and gray plugs. The skin lesions are usually on the face, but may involve the shoulders and chest, back and abdomen. Chloracne may develop 3 to 4 weeks after exposure and may last up to 15 years even if exposure stops. Complications include liver disease, bronchitis, nausea, vomiting, and diarrhea. **The nervous system can also be poisoned causing symptoms such as headache, fatigue, irritability, palm sweating and numbness of the legs.** Simple measures such as good personal hygiene, engineering controls and use of protective equipment can help prevent a person from developing occupational acne. (Bertolini et al, 1989)

## Study #30

- numbness in fingers/toes
- learning difficulties
- sleeping difficulties
- tremors
- unusual fatigue
- decreased sense of smell
- lung irritation
- peculiar odor/taste
- increased prevalences of nervousness
- irregular heartbeat
- bruising

A study was conducted on the incidence of health complaints among residents living in the vicinity of two Superfund sites contaminated with toxic chemicals, including PCBs. Residents living near the sites were classified as having high or low exposures to toxic chemicals at the dumping sites and the prevalences of 29 symptoms were compared between the groups. An increase of at least 50% in the prevalence of learning difficulties, sleeping difficulties, tremors, unusual fatigue, decreased sense of smell, lung irritation, and peculiar odor/taste was seen in the

high exposure group. In addition, the high exposure group reported increased prevalences of nervousness, **numbness in fingers/toes**, irregular heartbeat, and bruising that approached 50%. **Seven of the ten neurological symptoms studied were reported at least 50% more frequently in the high exposure group compared with the low exposure group.** Statistical analysis confirmed a clustering of excess reports of neurological symptoms among those in the high exposure group. The proportion of subjects in the high exposure group reporting five or more neurological symptoms was also twice that seen in the low exposure group. The authors conclude that this excess of neurological symptoms in residents with high exposure to these dumping sites is consistent with the known toxic properties of the chemicals contained at these sites. (Dayal et al, 1995)

### Study #31

- slower sensory conduction velocities
- slower distal sensory conduction velocities

The effect of polychlorinated biphenyl (PCB) on nerve conduction was studied in accidentally exposed workers. Exposure occurred when 15 electrical capacitors exploded in a cardboard factory. The capacitors were composed mainly of dichlorobiphenyls, trichlorobiphenyls, and tetrachlorobiphenyls. Air concentrations 5.5 hours after the accident ranged between 8,000 and 16,000 micrograms per cubic meter PCB. During the accident and during clean up, several workers were in probable contact with PCBs or their degradation products. Fifteen males with the highest probable exposure were studied neurophysiologically 2 and 6 months after the accident. Tests with skin electrodes were made of motor conduction velocities of the right median, ulnar, and peroneal nerves; sensory conduction velocity of the right sural nerve; and distal sensory conduction velocities of the right median and ulnar nerves. Thirty unexposed workers of similar age distribution were tested for comparison purposes. Motor conduction velocities were similar in both groups; however, 2 months after the explosion, **all sensory conduction velocities and distal sensory conduction velocities were slower** in the exposed group than in comparisons. At 6 months, the **distal sensory conduction velocity of the ulnar nerve and the sensory conduction velocity of the sural nerve were slightly slower** in the exposed group. Improvement between the test points indicated that the sensory conduction velocities were reversibly impaired. The authors conclude that PCBs exhibit neurotoxic properties in humans. (Seppalainen et al, 1985)

### Study #32

- neurophysiological methods were reviewed for detection of PCB neurotoxicity (1969)

The use of neurophysiological methods in the detection of early neurotoxicity in humans was reviewed. Methods discussed included electroencephalography, or the recording of the electrical activity of the brain; evoked potentials (EP) which study certain precise functions of the central nervous system such as visual EPs, auditory EPs, or somatosensory EPs; and electromyography, the measurement of nerve conduction velocities. The application of these various neurophysiological methods to determine possible exposure was discussed for the following substances: solvents such as carbon-disulfide (75150), n-hexane (110543), methyl-n-butyl-ketone (591786), toluene (108883), xylene (1330207), halogenated hydrocarbons, styrene (100425), solvent mixtures, other industrial solvents, and alcohol (64175); insecticides including organophosphorus compounds, chlorinated insecticides, and pyrethroids; selected chemicals such as acrylamide (79061), methyl-methacrylate (80626), **polychlorinated-biphenyls** (1336363), dioxins and phthalates; metals including lead (7439921), mercury (7439976), and arsenic (7440382); and drugs. (KUROIWA et al, 1969)

### Study #33

- nerve conduction velocities were slightly reduced, but returned to normal within 6 months
- vertigo (dizziness)
- smarting of the skin
- intensive sweating
- headache
- nausea
- irritation of the eyes and respiratory tract

A case study of a capacitor explosion that released polychlorinated biphenyls (PCBs) was examined. The accident took place in the electricity room of a large paper mill. Two strong explosions caused 15 employees to be heavily exposed to PCBs, and 150 employees were exposed to a lesser degree. Vacuum cleaning, pressure washing, wiping with organic solvents, repainting, and removal of wall and floor surfaces were among the cleaning methods used. PCB concentrations in air and soot were analyzed through chromatography. The health of the 15 heavily exposed workers was monitored for 7 months. The serum activities of aspartate-aminotransferase, alanine-aminotransferase, glutamyltranspeptidase, and alkaline-phosphatase were determined. Maximal conduction velocities of the peripheral motor and sensory nerves were measured. The clean up procedures produced approximately 100 tons of PCB containing waste. PCB concentrations in air declined from 10,000 micrograms (microg) per cubic meter at the time of explosion to less than 1 part per million 120 days later. PCB soot concentrations ranged from 200microg per gram (g) to 1microg/g. Acute symptoms experienced by exposed workers included nausea, irritation of the eyes and respiratory tract, vertigo, smarting of the skin, intensive sweating, and headache. These symptoms disappeared without treatment. Nine of the heavily exposed workers had at least one upper respiratory infection during the 7 months after the accident. Elevated serum activities were found for most of the subjects, but returned to normal within 4 weeks. Conduction velocities were slightly reduced, but returned to normal within 6 months. The authors conclude that equipment containing PCBs must be located and information must be given on accident prevention and management. (Elo et al, 1985)

### Study #34

- decreases in velocity and amplitude of conduction velocity of the median sensory and sural nerves.
- deficits in immediate auditory recall
- reduced visuo/spatial perception and logic
- reduced psychomotor reaction time
- impaired recent memory

Documenting forensic neurotoxicity cases was discussed. Evaluating neurotoxicity cases for litigation cases in the United States (US) has been increasing. Illnesses such as memory and personality disorders have been recognized by courts as legitimate causes for compensation; however, these cases usually required documentation by a neuropsychologist. It was noted that the level of certainty for litigation purposes is less stringent than for scientific studies. The usual criterion for probabilistic determination in scientific studies was beyond a reasonable doubt corresponding to a probability level of 0.05, whereas in US civil litigation the criterion was more probable than not, corresponding to the 0.50 probability level. The elements of a forensic neurotoxicity examination were illustrated using a case of a worker who suffered neurotoxic sequelae from exposure to polychlorinated-biphenyls (1336363) (PCBs). The subject was exposed to PCBs for 3 years at a metal salvage company that stripped copper coils from used electrical transformers. The subject noticed a deterioration in his health after a year's exposure. It was determined that before being employed by the salvage company the subject was in excellent physical and mental health. Neuropsychological and nerve conduction testing was performed and showed **deficits in immediate auditory recall, visuo/spatial perception and logic, psychomotor reaction time, and recent memory, and decreases in velocity and amplitude of conduction velocity of the median sensory and sural nerves.** The author concludes that neurotoxicity is documented in the subject after 3 years' exposure to PCBs at the salvage site.

Comprehensive neuropsychological testing can help in diagnosing suspected toxicity cases and is recommended when evaluating exposure to PCBs and other neurotoxic agents. (Singer, 1988)

### Study #35

- nerve conduction velocity testing is recommended as standard medical practice following PCB exposure

Appropriate medical surveillance of persons exposed to polychlorinated biphenyls (PCBs), chlorinated dibenzodioxins and dibenzofurans is discussed. Any worker who may have been exposed to such chemicals must have a thorough occupational medicine history and physical examination. Appropriate laboratory tests include: complete blood count with differential; serum chemistries; serial blood PCB determinations; fat biopsy to determine furan (110009) and dioxin (828002) concentrations; pulmonary function tests; chest X-rays; urinalysis including porphyrin (101600) measurement; and **nerve conduction velocity testing**. A consensus has not been reached as to the appropriate length of medical follow up after exposure. It is important that specialists with training and experience in occupational medicine and nursing conduct the medical surveillance programs. Measurements should be taken of the concentrations of the chemicals in the soot and air; these measurements should be compared with concentrations found in the blood and fat of exposed persons, particularly in the case of PCBs, furans, and dioxins. At present, no modality of treatment is known to be clinically efficacious in removing PCBs, furans, or dioxins from tissues or blood. The author concludes that yearly updates of medical procedures are essential to any medical surveillance approach. (Schechter, 1985)

### Study #36

- mildly decreased motor nerve conduction velocity
- paresthesia in the limbs
- impairment of superficial sensation
- ankle jerk was lost or decreased
- symptoms were not correlated with blood PCB concentration or the pattern of PCB

Patients (26) with Rice Oil Disease (Yusho), from accidentally ingesting rice oil contaminated with polychlorinated biphenyl (PCB) in summer 1968, were studied during the 1980 annual physical examination for rice oil disease (Japan). A total of 58% of patients still complain of headache, and severe headache is present in 12%. This rate did not differ from that found at the 1973 annual physical examination. **Paresthesia in the limbs** affected 46% of patients, the rate being similar to that reported in 1969. **Impairment of superficial sensation** was found in 8%, which was significantly smaller compared with the rate reported in 1969. Ankle jerk was absent in 15% and decreased in 19% of patients. This was more frequently found in patients with paresthesia than in those without. **Ankle jerk was lost or decreased** in a greater proportion of patients in the present series compared with that from the 1969 report but the aging factor of the patient population might be responsible for the apparent increase of the abnormality. The presence or absence of headache, limb paresthesia or ankle jerk was **not correlated with blood PCB concentration or the pattern of PCB**. In a patient who showed a **mildly decreased motor nerve conduction velocity (MCV) in the right ulnar nerve in 1968, the repeated study with the same technique in 1980 revealed normal MCV**. Nineteen percent of all patients had occasional attacks of colic-like abdominal pain for several years after the onset of the illness but few patients had the symptom recently. There was **no evidence of autonomic nervous system dysfunction**. (Shibasaki, 1981)

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## Upcoming Study

HARRY GJ. CELLULAR INDICATORS OF NEURONAL INSULT. Source: Crisp Data Base National Institutes Of Health. Author Address: NIEHS, NIH

- calcium homeostasis plays a critical regulatory role in cell-cell communication and signaling [PCBs alter calcium homeostasis]

Numerous receptor systems in various brain regions have been reported to be affected by toxicant exposure. This project will examine the role of toxicant-induced changes in receptors to functional changes in the cell such as the ability to maintain calcium homeostasis. This process plays a critical regulatory role in cell-cell communication and signaling. A disruption in intracellular calcium can disrupt the calcium-mediated signal transduction processes resulting in a cascade of intracellular effects. Intracellular calcium has been examined in subcellular components of the nervous system following exposure to environmental agents such as inorganic lead and polychlorinated biphenyls. Using a primary cell culture system of cerebellar granule cells, this project has examined the effects of PCBs on cellular calcium homeostasis in both a population of cells as well as individual cellular responses. Initial studies have examined the developmental ontogeny of the second messenger system in the visual system. Alterations in this profile will be studied as a measure of visual sensory functioning in the developing animal following exposure to an environmental agent. Immunohistological studies are underway to examine alterations in neuronal distribution of a calcium binding protein, Calbindin 28K, and its potential role in determining the cellular pattern of perturbation in the nervous system either following exposure to an environmental agent or during the aging process.

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## Studies Without Abstracts

KADUSHIN FS, RIDDLE MW, BRONSTEIN AC, GILMORE DA. NEUROPSYCHOLOGICAL FINDINGS IN WORKERS EXPOSED TO 1 1 1 TRICHLOROETHYLENE AND POLYCHLORINATED BIPHENYLS. Source: SCIENTIFIC MEETING OF THE AMERICAN ASSOCIATION OF POISON CONTROL CENTERS, AMERICAN ACADEMY OF CLINICAL TOXICOLOGY, AMERICAN BOARD OF MEDICAL TOXICOLOGY, AND CANADIAN ASSOCIATION OF POISON CONTROL CENTERS, BALTIMORE, MARYLAND, USA, OCTOBER 1-4, 1988. VET HUM TOXICOL; 30 (4). 1988. 361. Key words: HUMAN COGNITION, MOTOR ABILITY, NEUROPATHY, DIAGNOSIS

KUROIWA Y, MURAI Y, SANTA T. NEUROLOGICAL AND NERVE CONDUCTION VELOCITY STUDIES ON 23 PATIENTS WITH CHLOROBIPHENYLS POISONING. Source: FUKUOKA ACTA MED. 1969, 60(6) 462-463 (JPN) EIS: Epidemiology Information System

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