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Review: EEG and Pesticides

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Two main groups of xenobiotics used as pesticides are the organophosphates and the chlorinated hydrocarbons. The neurologic symptoms exhibited by exposure to these compounds are subjective and difficult to correlate with a particular chemical. The electroencephalograph can provide an objective assessment as well as follow-up for patients exposed to these toxic chemicals.

Organophosphates

Organophosphates are used as insecticides, for which purpose, similar to other pesticides, a relatively high insect toxicity is required and a relatively low human toxicity is essential. Interestingly enough, some organophosphates have been used for the management of myasthenia gravis and glaucoma; however, the therapeutic window is much too narrow for safe use. Some of the more toxic organophosphates have been stockpiled as "nerve gases" supposedly intended for chemical warfare.

Based on volume of production and sales, organophosphates are currently one of the most widely applied pesticides. Their usage over the last two decades has increased with growing legislation to restrict the use of chlorinated hydrocarbon insecticides (CHI) such as DDT, aldrin, endrin, dieldrin and chlordane. Acute, chronic (delayed) and intermediate syndromes are known to occur with organophosphate intoxication.[1,2] The significant neurotoxicity of organophosphates has been recognized for many years. The toxicity is caused in part by an accumulation of acetylcholine at synapses as a result of the irreversible binding of the acetylcholinesterase with the organophosphate substance. Acetylcholinesterase is the enzyme responsible for the breakdown of acetylcholine. The organophosphates also bind pseudocholinesterase. Acetylcholinesterase is found in the brain, the peripheral nervous system and erythrocytes. Pseudocholinesterase is found in liver and plasma. Clinical symptoms from chronic exposures to organophosphates include impaired memory, motor and sensory symptoms, peripheral neuropathy, depression, decreased concentration and attention span and psychotic symptoms. There is a characteristic sequence of EEG patterns in alkylphosphate intoxication that clearly has potential as a diagnostic tool. EEG changes consist of nonspecific enhancement of slow activity and paroxysmal changes.[3]

Chlorinated Hydrocarbons

In contrast to the organophosphates, the chlorinated hydrocarbons do not have as clear a mechanism for neurotoxicity. These compounds are highly fat soluble and can be found in fat tissues for years after exposure. Even though CHI generally have a relatively low toxicity, but because they bio-accumulate, there is a potential for toxicity. Neurological symptoms consist of tremor, hyper-irritability, dizziness, ataxia, gastrointestinal symptoms, numbness, tingling and myoclonic jerking seizures.

The majority of the literature on human EEGs and CHI exposure are reports from clinical observations. Experiments with control groups are less commonly documented. One such study consisted of a test group of 122 chemical plant workers receiving chronic, on the job, exposure to dieldrin, endrin and aldrin.[4] EEG results of this group were compared to a control group of 122 office workers. The control group had EEG abnormalities in 9% of the subjects versus 20.5% with abnormalities in the exposed group. Fourteen of the exposed patients with EEG abnormalities also had convulsions; these subjects all showed specific EEG anomalies consisting of bilateral synchronous theta wave activity and occasional bilateral synchronous spike and wave complexes. These specific patterns had a tendency to return to normal within six months after removal from the chemical toxicant.

EEG abnormalities from aldrin, dieldrin, and endrin in this study were very specific and were used by the authors as a diagnostic tool for identifying intoxicated workers, some of whom were asymptomatic. Furthermore, in this study, all subjects that were suspected to be intoxi-

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cated based on complaints of subjective symptoms were found to have EEG abnormalities. Studies conducted by other researchers failed to reach similar conclusions.

Another study concluded that following exposure to aldrin and dieldrin, the EEG showed diffuse abnormalities rather than specific findings.[5] A more recent report described an excess of slow waves, spike activity and paroxysmal bursts of delta wave abnormalities in the EEGs of six patients after chronic consumption of aldrin and BHC (benzene hexachloride) in wheat flour.[6]

EEG recordings of 73 DDT production workers showed normal records for 78% of the subjects and abnormalities in 21%.[7] Abnormalities consisted primarily of bitemporal sharp waves, sometimes associated with anterior slow activity. These workers were asymptomatic.

Variations in EEG abnormalities from exposure to different chlorinated hydrocarbons is further complicated by the potential for synergistic effects of these compounds which are often used in mixtures. Chronic versus acute exposures may also present varying EEG patterns. Animal studies (rat) demonstrated initial EEG abnormalities when exposed to chronic low doses; however, these abnormalities disappeared after several weeks even with continued exposure suggesting the development of some form of tolerance.[8] In humans, it is possible that these neurotoxicants are handled differently in chronic exposures as opposed to shorter term exposures. These differences may lead to variability in cases of full-time, chemical plant workers and seasonally exposed agricultural workers.

A variety of different subjective symptoms are noted suggesting individual variability and susceptibility which may be related to enzyme metabolic rates. There may also be an increased susceptibility in the pediatric age group.[9] A six month old infant was exposed to high levels of chlordane, and subsequently developed an intractable seizure disorder. The serum chlordane level was 180 PPB (0.18 μg per ml blood) approximately two years after exposure. One EEG during an awake period showed almost continuous high voltage bisynchronous spike and wave activity. Another EEG during sleep showed frequent synchronous discharges of spike and wave activity, some with 3 Hz high amplitude anterior distribution. This particular infant does have a positive family history of febrile convulsions, which needs to be considered as a confounding variable, and perhaps raises the possibility of increased susceptibility not uniquely environmental but based on hereditary factors also. A similar case has come to the author's attention. A nineteen month old infant developed seizures after being exposed orally and topically to an unknown quantity of chlordane. The serum chlordane level was 350 PPB (0.35 μg per ml blood). Although a single electroencephalogram performed one week after the incident was normal, this infant subsequently developed a chronic seizure disorder.[10]

At this point, our understanding is limited and it is difficult to make a specific diagnosis based only on the EEG with regard to toxic exposures. Because of recent developments in computerized quantitative EEGs with functional brain mapping, the future of diagnostic electroencephalography in the area of neurotoxicology is promising.

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