Vulnerability of the auditory system

Despite the protective mechanisms that most often prevent damage to the inferior colliculus, the inferior colliculus is involved in brain damage from many causes. The resemblance of damage to Wernicke's encephalopathy has on rare occasions been noted [1, 2]. Wernicke-like pathology is often the result of catastrophic situations in which protective mechanisms have no chance to go into action. Rapid intoxication with alcohol, inhalation of poisons like methyl bromide, and asphyxia by suffocation or cardiac arrest are all catastrophic events associated with injury of brainstem pathways including the inferior colliculi [3, 4].

Deficiency of thiamine (vitamin B1) is among the best known causes of brain damage involving the inferior colliculi. Figure 21 is from the paper by Vortmeyer et al. (1992) and shows severe hemorrhagic damage in the inferior colliculi of a terminally ill person maintained on parenteral (intravenous) feeding in which thiamine supplement had been omitted [5]. Thiamine is an essential cofactor for several enzymes that catalyze aerobic metabolism; its importance is discussed further in the following chapters. Rapid depletion of thiamine during maintenance on intravenous feeding can also be considered a catastrophic event, barely less serious than suffocation.

Aerobic metabolism is totally disabled when cofactors like thiamine for aerobic enzymes are removed, or when these enzymes are damaged by poisonous substances. The hazards of environmental toxins such as mercury and lead are currently receiving a great deal of attention. Direct poisoning or denaturing of aerobic enzymes is as catastrophic an event as depletion of cofactors or asphyxia. Protective biofeedback mechanisms cannot preserve metabolic functions in brain areas of high metabolic rate if the enzymes that accomplish metabolic transformations are rendered non-functional.

Oyanagi et al. (1989) examined the brains of fourteen people who died from exposure to methyl mercury [6]. These patients exhibited signs of Hunter-Russell syndrome (or Minamata disease) which includes ataxia and impairments of hearing and speech, and is known to involve damage of the auditory receptive areas of the temporal lobes. Oyanagi et al. found degeneration of auditory nuclei in the brainstem in addition to temporal lobe damage.

Sokoloff et al. (1977) modified the autoradiographic method for measuring blood flow to measure glucose uptake [7]. They used radioactive deoxyglucose as the tracer, which is taken up in the brain like glucose but not metabolized further. This method has been used by many researchers to study changes in metabolism resulting from drugs and other factors that impair brain function.

Bertoni and Sprenkle (1988) investigated the effects of lead poisoning in laboratory rats by measuring its effects on glucose uptake in the brain [8]. They found a decrease in cerebral metabolism throughout the brain, which was most significant in auditory nuclei of the brainstem. Burchfield and Abrams (1993) also used the deoxyglucose method to investigate
the effects of cocaine on fetal sheep [9]. They noted a reduction of glucose uptake in all regions of the brain, except in frontal gyri of some of the experimental animals. However, the data they present indicate the greatest reduction in brainstem nuclei of highest metabolic rate such as the inferior colliculus, inferior olives, and mammillary bodies.

Reports of brain damage caused by the toxic substance methyl bromide made special note of serious involvement of the inferior colliculi [3, 10, 11]. Alpha-chlorohydrin is a chemical substance once under development as a male contraceptive, until its unacceptable side-effects were discovered [12]. It has since been found to cause precisely localized, symmetrical damage limited to the inferior colliculi, superior olives, and red nuclei in experimental animals. By increasing the dose or giving repeated small doses more widespread damage could be produced.

The anti-cancer drug, Carboplatin has been found to damage the inferior colliculi [13]. The antimicrobial drug metronidazol (Flagyl) was found in one study to cause a Wernicke-encephalopathy-like pattern of damage in rats that involved the superior rather than the inferior colliculi [14]. An experimental anti-tumor drug, erbulozole, caused clinical signs of Wernicke encephalopathy in two human patients [16, 17]. Use of the deoxyglucose method might be prudent in the testing of chemical substances used widely for any purpose, but especially those used as medications.

The auditory system and other brainstem nuclei of high metabolic rate have been shown in the reports mentioned above to be selectively vulnerable to toxic substances as well as asphyxia. This vulnerability is discussed in more detail in the chapters that follow. The high rate of cerebral blood flow exposes nuclei in the auditory system to greater amounts of circulating toxins, and sooner than less well perfused areas of the brain. The auditory system is clearly vulnerable to many noxious factors, and impairment of auditory function would seem likely to be involved in cases of autism resulting from toxins or infections that disrupt brain metabolism during early development.

A popular theory is that use of lead (plumbing) in aqueducts and drinking of wine from lead vessels may have led to the fall of the Roman Empire. An alarming rise in cases of autism has become evident in recent years and an association of autism with prenatal exposure to alcohol, "recreational" drugs, prescribed medications such as valproic acid, and vaccines preserved with mercury compounds. Could ignorance of the hazards of toxic chemicals lead to the fall of our own civilization?

References
4. Janzer RC & Friede RL (1980) Hypotensive brain stem necrosis or cardiac arrest encephalopathy?
10. Franken L (1959) Étude anatomique d’un cas d’intoxication par le bromure de méthyle.
Figure 21: Hemorrhagic damage of the inferior colliculi caused by thiamine deficiency (from Vortmeyer et al. 1992).