Study Talks

Rat Brain Damage from Mobile Phone Use

The idea that frequent exposure to the electromagnetic fields (EMFs) generated by mobile phones could cause adverse health effects has taken on the status of urban myth in many people's minds due to the lack of definitive scientific evidence. But startling new findings by a team of researchers from Lund University in Sweden make the issue once again a cause for genuine concern—and suggest it might be time to get serious about using your headset when talking on your mobile phone and encouraging your family members to do the same [***EHP*** **111:881–883**].

Previous research in the field has concentrated on the potential association between exposure to radio-frequency (RF) EMFs and cancer. Studies with that end point have shown either no effects or even a decreased risk. The Swedish team, led by Leif G. Salford, has taken a different approach, focusing on the possibility that such exposures could cause damage to the brain itself. Prior experiments by the group with a rat model had shown that RF EMF exposure significantly breached the animals' blood–brain barrier. This allowed the plasma protein albumin to pass out of the bloodstream and into the brain, accumulating in the neurons and glial cells surrounding the capillaries. In their new study, the investigators address the question of whether this leakage of albumin could damage brain tissue.

The investigators exposed 32 rats to controlled doses of RF EMF generated by a Global System for Mobile Communications mobile phone (a type commonly used in Europe). The rats were divided into 4 groups and exposed for 2 hours each to power outputs of 0 (control), 10, 100, or 1,000 milliwatts, exposure levels that are roughly comparable to what a human mobile phone user might receive over the same time period. The animals' brains were examined 50 days after the single exposure.

As expected, a large proportion of the exposed rats showed evidence of albumin leakage. In this experiment, however, the Swedish team also found that the albumin appeared to cause significant and serious neuronal damage. "Dark" neurons, which appeared shrunken and homogenized, with loss of discernible internal cell structures, were seen in all locations of the exposed rats' brains, particularly in the cortex, hippocampus, and basal ganglia. The number of dark neurons discovered was significantly and positively associated with the RF EMF dose received by the animals.

The authors acknowledge that their study sample was small, but state that "the combined results are highly significant and exhibit a clear dose–response relation." The rats used were 12–26 weeks old, comparable in age and development to human teenagers, who the authors note are "notably frequent users of mobile phones." As the group points out, the biologic and maturational processes taking place in the growing brain are particularly vulnerable to damage from exposures of this type. Although they admit that neuronal damage like that seen in this study may not have immediately demonstrable consequences, they are worried about the long-term effects of frequent RF EMF exposure: "We cannot exclude that after some decades of (often) daily use, a whole generation of users may suffer negative effects [including reduced brain reserve capacity], perhaps as early as middle age." **–Ernie Hood**

A word of caution? Research on rats suggests that heavy use of mobile phones may put people at risk for neuronal damage.

Stockbyte

It's All in the Mix

Proving Adverse Effects of Fine and Ultrafine PM

The association between exposure to airborne particulate matter with a median diameter of 10 micrometers (μm) or less and increase in respiratory disease has been well established, although the physical and chemical properties involved remain unknown. Suspicion has been growing that exposure to even smaller particles, in the fine (2.5–10 μm) and ultrafine (less than 0.1 μm) ranges, might be even more likely to cause adverse health effects. Until recently there had not been a reliable method available to recreate the particulate mix in ambient air—especially the ultrafine particles—in sufficient concentrations to allow analysis in a controlled setting. Now, however, using advanced technology to recreate such a particulate mix, Kevin R. Smith from the University of California, Davis, and colleagues have proven adverse respiratory effects of fine and ultrafine concentrated ambient particles (CAPs) on healthy adult rats [***EHP*** **111:902–908**].

The researchers used a newly developed device called a Versatile Aerosol Concentration Enrichment System (VACES). This system can enrich the concentration of ambient particles in selected size ranges of 0.01–10 μm by up to a factor of 40, depending on the desired output flow rate, while preserving the characteristics of the component particles during the process.

Smith and his group exposed groups of 6 rats to either filtered ambient air (as control) or to ambient air with enriched particle concentrations created using the VACES. The procedures were conducted in Fresno, California, which lies in a region known to have some of the highest ambient particle concentrations in the United States, particularly in the $PM_{2.5}$ range. The enriched ambient fine and ultrafine particle concentrations were approximately 20-fold higher than outdoor concentrations at the Fresno test site.

Exposures were for 4 hours per day for 3 days, during 1 of 3 consecutive weeks of fall 2000 and 3 consecutive weeks of winter 2001. Immediately following the third day of exposure, the researchers conducted bronchoalveolar lavage (BAL) on the animals, washing their lungs with a neutral solution and then determining the nature and number of bronchial cells washed into the lavage fluid. This allowed them to determine whether exposure to the fine and ultrafine CAPs had a cytotoxic or proinflammatory effect upon the lungs.

For rats that were exposed during the first week of winter, exposure to CAPs was associated with a significant increase in the total number of cells recovered by lavage compared with the controls for that week. This same group also had a significantly higher number of BAL macrophages, as well as a significant increase in the number of neutrophils. The CAPs-exposed group for the first week of fall also had a significant increase in BAL neutrophils. Although a clear dose response could not be established, the highest levels of particulate matter mass, nitrate, and organic carbon

were measured in the ambient air during the 2 weeks when the increases were greatest.

The CAPs-exposed animals exhibited increases in other markers of lung damage compared to the control groups, although none of these markers achieved statistical significance. The researchers also measured BAL cell permeability, an indicator of decreased membrane integrity, and determined that the proportion of nonviable BAL cells increased significantly in the CAPs-exposed groups compared to controls in 4 of the 6 test weeks.

The authors did not attempt to correlate particle components with health effects, but did uncover striking evidence of "consistent cytotoxic and inflammatory responses associated with exposure to CAPs." It is also noteworthy that this detectable exposure-related lung damage occurred in healthy adult rats, in contrast to some previous studies that utilized rat models with respiratory diseases. Perhaps most importantly, the authors achieved their findings through the use of a potentially powerful new tool in the analysis of the impact of ambient exposure to fine and ultrafine particulate matter. **–Ernie Hood**

Shorter Cycles

Trihalomethanes and Menstruation

Prompted by increased concerns about the health effects of chlorination by-products, a team of researchers led by Gayle C. Windham of the California Department of Health Services studied tap water consumption in a sample of Northern California women, and found that higher chlorination by-product concentrations in water were associated with a decrease in menstrual cycle length [***EHP* 111:935–941**]. The Women's Reproductive Health Study is the first study to examine menstrual cycle function relative to tap water concentrations of trihalomethanes (THMs), the chlorination by-products most commonly measured in quarterly monitoring by water utility companies. The study also examined reproductive health effects from a number of other exposures, such as smoking and chemical solvent exposure.

THMs have been found in previous studies to be associated with adverse pregnancy outcomes including miscarriage and low birth weight. To find out if THMs are associated with other reproductive end points such as menstrual function, as well as to pinpoint possible mechanisms, the team evaluated data from the Women's Reproductive Health Study in a sample consisting of 403 married women aged 18–39 in Northern California.

After reporting lifestyle information and daily water drinking habits, the women collected and froze first-morning urine samples for the duration of 2–9 menstrual cycles and kept a daily diary to record, among other items, timing of menstrual bleeding (menses). The research team analyzed daily urine samples for estrogen and progesterone metabolites using enzyme-linked immunoassay. This gave them clues about each woman's ovulatory status; the day of ovulation was estimated using an accepted algorithm that selects the day after the peak of the estrogen-to-progesterone ratio. They analyzed cycle length variability and mean length of menstrual cycle, follicular and luteal phases, and menses.

The team also estimated total THM (TTHM) concentrations in tap water based upon an average of measurements taken by each of 10 water utility companies in the study area. The researchers gathered quarterly monitoring data of THM concentrations collected at various points in each utility's distribution system. They calculated concentrations for each of 4 individual THM compounds—bromoform, chloroform, chlorodibromomethane, and bromodichloromethane. They added individual THM compounds to calculate TTHMs and used those data to estimate TTHM concentrations in each woman's water supply during each menstrual cycle. They also added just the 3 brominated compounds for a separate estimate.

The researchers examined numerous potential confounders, including smoking, alcohol and caffeine consumption, pregnancy history, body mass index, age, race, education, income, and employment. They found very little evidence for confounding of TTHM effects on mean cycle length. Only 3% of the participants had average TTHM concentrations above the U.S. Environmental Protection Agency's annual maximum contaminant level of 80 micrograms per liter (µg/L). For this study, high exposure was defined as 60 µg/L or higher per day.

Overall, the investigators found a decrease in cycle length of 0.18 days per 10-µg/L increase in TTHMs, with the most highly exposed cycles 1 day shorter after adjustment for variables. The decrease stemmed from shorter follicular phase length; little difference was seen in luteal phase or menses duration. High concentrations of the 3 brominated by-products together significantly decreased cycle length—by 1.2 days at the highest exposure level. Chloroform concentrations were not associated with a significant decrease in cycle length.

The shortened follicular phase presumably indicates a change in ovarian function, including earlier ovulation. This potentially could affect maturation of the egg, thickening of the uterine wall, and timing of when a woman is more or less likely to conceive—that is, the likelihood of getting pregnant. The team recommends future studies to confirm this possibility. **–Jennifer Medlin**

Image Source

A clearer understanding. Findings indicate that the presence of high concentrations of chlorination by-products in drinking water can affect menstruation.