



**Disclaimer:** This newsletter, provided by ITIS, is funded by a grant from the Illinois Department of Public Health and supported by Northwestern Memorial Hospital and Northwestern University Medical School. It is for educational purposes only and is meant to summarize the information available at the time of its creation. It should be construed neither as medical advice nor opinion on any specific clinical situation. For more information on a specific clinical situation, or updated information, please consult your health care provider.

## **Carbon Monoxide and Pregnancy**

Vol 3#5, June 1995

Eugene Pergament, MD, PhD; Amy Schechtman, MS; Patti Lynn Mills

Recently many locales have instituted regulations requiring residential buildings to be equipped with carbon monoxide (CO) detectors. These detectors alert residents to dangerous levels of carbon monoxide in the air. An indication of potentially harmful levels of CO in the air is of concern to pregnant women as well as the general population. This RISK||NEWSLETTER will address how maternal exposure to carbon monoxide can affect fetal development.

### **BACKGROUND INFORMATION**

Carbon monoxide is a colorless, odorless and tasteless gas present in furnace gas fumes, automobile exhaust, cigarette smoke and the exhaust of some industrial plants and refineries. CO also is produced endogenously in humans. The production of endogenous CO increases during pregnancy, reaching levels between 0.5% and 1.0%. When inhaled, CO from the air reacts with hemoglobin to form carboxyhemoglobin. The affinity of CO for hemoglobin is greater than that of oxygen. The presence of carboxyhemoglobin in the blood inhibits the necessary transportation of oxygen to the cells of the body. The brain is very sensitive to the deprivation of oxygen. Symptoms of CO exposure in adults can range from headache, drowsiness and weakness to coma, permanent brain damage or death, depending on the level of CO in the air and the duration of the exposure. Signs of CO toxicity are indicated in the following table.

Sudden exposure to high concentrations of CO can be associated with drowsiness, dizziness, muscular paralysis, coma and death due to respiratory failure.

Long term exposure to low levels of CO may cause mild to moderate symptoms as listed in the table. Other symptoms can include flushed, blotchy, red face, neck and chest as well as blurred vision, mental depression, loss of appetite, nausea, slurred speech, and breathing difficulties. Eventually, such an exposure could lead to death.

### **EFFECTS OF CO EXPOSURE IN PREGNANCY**

As with any environmental exposure, when attempting to determine whether an exposure is likely to have a teratogenic effect on a developing fetus, it is important to determine when in the pregnancy the exposure occurred as well as the duration and the extent of the exposure. Without the knowledge of CO levels in the air, or carboxyhemoglobin levels in an exposed individual's blood, the extent of CO exposure is difficult to determine. As air and blood levels are difficult to obtain, often the severity of maternal toxicity is used to gauge the degree of exposure. Toxicity can also provide clues as to the duration of the exposure.

Studies of human reports suggest that CO exposures that are harmful to a fetus are generally toxic to the mother. In pregnant women, CO poisoning resulting in symptoms indicating severe maternal toxicity (such as CO induced loss of consciousness) has been associated with intrauterine fetal death or neurological disorders in surviving infants (Caravati et al., 1988; Koren et al., 1991). One multicenter prospective study reported that 31 pregnancies in women who experienced mild to moderate CO poisoning resulted in the births of unaffected babies (Koren et al., 1991). The authors described the level of toxicity of women who experienced symptoms related to CO exposure but who remained alert as “mild to moderate poisoning”. This report also included 5 women who experienced severe poisoning. Two of the pregnancies were lost. One infant was born with cerebral palsy. Two women had apparently unaffected babies. These two women were treated with hyperbaric oxygen. There have been other reports in the literature of pregnancies unaffected by maternal CO poisoning (Carvati et al., 1988; Copel et al., 1982).

As maternal toxicity due to CO monoxide exposure may be associated with adverse pregnancy outcome, it is important to determine if an expectant mother experienced any symptoms due to her exposure. Because pregnant women in general can experience symptoms suggestive of CO poisoning (i.e. nausea, vomiting and drowsiness) it is helpful to determine if any non-pregnant adults with the same exposure experienced side effects related to CO poisoning. Children are considered more susceptible than adults to CO toxicity. If a mother and those around her report either no or very mild side effects, it is unlikely that the exposure would adversely affect the pregnancy.

Studies involving rabbits suggest that maternal exposure to CO above 90 ppm (0.09%) can adversely affect fetal and neonatal weight gain, while levels above 180 ppm are associated with an increased rate of pregnancy loss (Astrup, 1972). Singh and Scott (1984) noted decreased fetal weights in mice after maternal CO exposure over 150 ppm. The authors of one study in which pregnant mice and rabbits were exposed to CO at a level of 250 ppm concluded that the exposure did not have a teratogenic effect, although there was some increase in minor skeletal anomalies (Schwetz et al., 1979). As a point of reference, prolonged exposure to CO air levels of 50 ppm will cause human blood carboxyhemoglobin levels to reach 8 to 10%, as will smoking 20 cigarettes per day.

Warkany (1971) reviewed the literature pertaining to reports of human fetal brain or neurological damage due to maternal CO exposure and was not able to correlate the timing of the exposures in pregnancy to improper development of the central nervous system (CNS). However, most of the CNS maturation takes place in the later part of a pregnancy, suggesting that later exposures may cause CNS damage. Additionally, it has yet to be determined what level of CO exposure is sufficient to affect neurological development (Longo, 1977). CO exposure late in monkey fetal development can cause hemorrhagic necrosis of the fetal cerebral hemisphere (Ginsberg and Meyers, 1976). Interestingly, the CO exposures in this study were not sufficient to cause maternal toxicity. Likewise, CO exposures elevating the blood carboxyhemoglobin levels of pregnant rats to 15% were sufficient to cause behavioral changes in the offspring of these rats (Fechter and Annau, 1977). Additional studies have reported possible CO induced memory deficits and neurological deficits in rats and mice respectively (Robkin et al., 1976; Singh, 1986).

## CIGARETTE SMOKE

CO is a component of cigarette smoke. Pregnant women who smoke can have blood carboxyhemoglobin levels ranging from 2% to 14%. The carboxyhemoglobin levels in the blood of a neonate born to a smoker can reach 10%, which is over 10 times that found in a neonate born to a non-smoker (Longo, 1977). Studies of pregnant rabbits and mice exposed to CO suggest that the exposures might be associated with low birth and fetal weight respectively (Astrup et al., 1972; Singh and Scott, 1984). Cigarette smoke is also thought to be associated with low birth weight. Some authors suggest that CO in cigarette smoke might contribute to this effect. However, at this time it is unclear which

component(s) of cigarette smoke contributes to the low birth weight of infants born to smokers.

## SUMMARY

When trying to determine the teratogenic potential of a maternal exposure to carbon monoxide, consideration of the toxicity of the exposure is of considerable importance. Exposures that have not caused a toxic reaction in the mother or those around her are unlikely to affect her pregnancy adversely. Animal and human studies suggest that maternally toxic exposures leading to CO poisoning during a pregnancy may lead to pregnancy loss or neurological damage in the offspring. To determine the potential effect to the fetus is more difficult when a mother or adults around her experience very mild to moderate symptoms due to their exposure to CO. Studies suggest these exposures are unlikely to have an adverse effect on most pregnancies. However, animal studies and human case reports indicate that exposures causing very mild to moderate maternal symptoms might result in the birth of a child with neurological damage. Whether or not a fetus is affected by such an exposure may depend on when the exposure occurred during the pregnancy and/or the extent of the exposure. However, the critical time period(s) and levels have yet to be identified. A study of monkey fetal CO exposures suggests a critical time period might be late in a pregnancy, but this has not been confirmed by a review of human reports.

There is some evidence from animal studies that maternal CO exposure is associated with impaired fetal growth and low birth weight. As CO is one component of cigarette smoke, some authors have suggested that it may contribute to the presence of low birth weight in newborns of mothers who smoke.

## CARBOXYHEMOGLOBIN LEVEL IN BLOOD

### DEGREE OF TOXICITY

#### SYMPTOMS

<10%

10-20%

20-40%

>40%

None

Very mild

Moderate to severe

Potentially fatal

Slight headache

Shortness of breath during exercise

Severe headache

Vertigo

Tightness around head

Fatigue

Diplopia

Tightness in chest

Noise in ears

Pink color to blood

Coma

Convulsion

Death by respiratory arrest

Adapted from the Handbook of Emergency Toxicology (Fifth Edition), 1988