be an acid mucopolysaccharide.

The thiazide story, like the universe, is still unfolding. There are still wide gaps in our knowledge concerning many aspects of the use of thiazide agents. To give only a few examples, more needs to be known about the correlation between biochemical response and therapeutic efficacy, the significance of little-known thiazide effects such as magnesium and zinc deficiency has yet to be determined, and the failure of the drug in a small proportion of treated patients must still be explained. However, the point has surely been reached at which it can be stated unequivocally that hydrochlorothiazide is highly effective in preventing calcium stones and merits serious consideration for a prominent role in the modern management of this disorder. It is hoped that in the not too distant future, experts in this field will come to some consensus concerning the relative merits of this agent with respect to others such as orthophosphates and cellulose phosphate, which are also in current use, so that the medical profession will be able to apply these new developments more effectively in the management of their patients.

E.R. YENDT, MD
M. COHANIM, MD
Department of medicine
Queen's University
Kingston, Ont.

References

1. *Hospital Morbidity 1970,* cat no 82-206, Ottawa, Statistics Canada, health division, 1973, p 92
2. FRASER RD, SPASOFF RA, PRIME MG: *Toward the Establishment of Health Research Priorities: an Estimate of the Economic Burden of Ill-Health,* Toronto, Ontario Council of Health, 1976
3. YENDT ER, COHANIM M: The management of the patient with calcium stones. *Br J Urol* 48: 507, 1976
4. YENDT ER, GUAY FG, GARCIA DA: The use of thiazides in the prevention of renal calculi. *Can Med Assoc J* 102: 614, 1970
5. YENDT ER, COHANIM M: Ten years' experience with the use of thiazides in the prevention of kidney stones. *Trans Am Clin Climatol Assoc* 85: 65, 1973
6. Idem: Prevention of calcium stones with thiazides. *Kidney Int* (in press)
7. COE FL: Treated and untreated recurrent calcium nephrolithiasis in patients with idiopathic hypercalciuria, hyperuricosuria, or no metabolic disorder. *Ann Intern Med* 87: 404, 1977
8. PAK CYC: Hydrochlorothiazide therapy in nephrolithiasis. Effect on the urinary activity product and formation product of brushite. *Clin Pharmacol Ther* 14: 209, 1973
9. MEYER JL: Expitaxy, in *Idiopathic Urinary Bladder Stone Disease,* Fogarty International Centre Proceedings no 37, DHEW publ no (NIH) 77-1063, VON REEN R (ed), Bethesda, Md, Dept of Health, Education, and Welfare, 1977, p 83
10. ROBERTSON WG: Physical chemical aspects of calcium stone formation in the urinary tract, in *Urolithiasis Research, International Symposium on Urolithiasis Research, Davos, Switzerland, 1976,* London, Plenum Pr, 1976, p 25
11. COHANIM M, YENDT ER: Reduction of urine oxalate excretion during chronic thiazide therapy (abstr). *Clin Sci* 24: 685A, 1976
12. HOWARD JE: Studies on urinary stone formation: a saga of clinical investigation. *Johns Hopkins Med J* 139: 239, 1976

Carbon monoxide in the modern society

Despite the technologic advances in this century carbon monoxide remains a common cause of fatal poisoning,[1] and our technology may increase the risks.[2]

Carbon monoxide is an asphyxiant gas that diffuses readily in the air and is insidious because it has neither colour nor odour. Although other products of incomplete combustion may produce an odour or unpleasant fumes, these often provide insufficient warning to the individual at risk. Carbon monoxide diffuses across the alveolar membrane and binds to hemoglobin. Since hemoglobin has 200 to 300 times more affinity for carbon monoxide than for oxygen, the oxyhemoglobin dissociation curve is shifted to the left and the tissue oxygen tension must decrease before the remaining oxyhemoglobin can give up its oxygen.[3] Although it has been suggested that carbon monoxide may have some adverse toxic effects of its own,[4] the pathologic effects of carbon monoxide appear to be due to hypoxia from the reduced oxygen-carrying capacity of the blood.[5]

The "background" carbon monoxide in our blood may come in small part from the endogenous metabolism of heme, but most comes from exogenous production. Maugh[6] has argued that the amount of carbon monoxide produced by the processes of plant growth and death dwarf man's production on a global basis, but nevertheless there has been increasing concern in recent years about the large amounts produced by household fuels and automobile exhaust.

The current energy crisis has led to repeated requests that people reduce their fuel consumption. We have been advised, for example, to make our houses airtight so that heat is preserved. In following this advice many people have substantially reduced the ventilation in their homes. At the same time, many have resorted to using fireplaces for heat to reduce fuel costs. This can prove to be hazardous because the airtight home does not allow adequate air flow to the fireplace, and backdraught may bring some of the products of combustion into the room. If combustion is incomplete owing to poor oxygenation, the build-up of carbon monoxide in an airtight room can reach dangerous concentrations. The danger may be compounded by the use of inappropriate fuels such as charcoal briquettes, which generate large amounts of carbon monoxide if ventilation is poor.

In recent years much attention has been given to the large amounts of carbon monoxide produced by automobiles; it is estimated that in New York City automobile traffic alone produces 3.7 million kilograms of carbon monoxide daily.[7] High concentrations of carbon monoxide along city streets and freeways have caused concern for the safety of automobile drivers.

Most cases of acute carbon monoxide poisoning probably are not recognized, and the nonspecific symptoms of headache, fatigue, irritability, dizziness, paresthesia and disturb-

ances of consciousness are explained away in some other fashion. Persons who recover from carbon monoxide poisoning often have few sequelae, but a neurologic deficit may result, as it may from any long-term hypoxic event. It is estimated that approximately 150 Canadians and 600 Americans die each year from carbon monoxide poisoning. There are probably other deaths due to carbon monoxide that are not diagnosed correctly. Most of these deaths result from automobile exhaust fumes in closed garages or from cars parked with the engine running. Other deaths involve improperly operated heaters, usually with insufficient air flow or poor ventilation resulting from poor burner design, blocked air entries or backdraughting due to negative pressure or airtightness.

Probably the heaviest nonindustrial exposure occurs in individual smokers: a heavy smoker may have a carbon monoxide blood value of 5%, a person smoking up to three packs of cigarettes per day may have values of up to 9%, and a heavy smoker of cigars may have values as high as 20%.[2] Smoking adds to the background concentration of carbon monoxide in our blood that is already causing concern. Background carbon monoxide concentrations are of particular concern in areas such as Calgary[7] that have high-density automobile traffic, weather inversions, high altitude and cold weather.

Many deaths have been reported from use of hibachis or barbecues indoors. Wilson, Rich and Messman[8] reported five deaths over a 14-month period in Utah from the burning of charcoal briquettes inside a Volkswagen bus, a trailer, a station wagon and a potato cellar. They also had information on five other deaths from the use of charcoal briquettes in enclosed, poorly ventilated spaces. More recently, the hazard created by people using their barbecues in indoor fireplaces because of poor weather outside has been recognized. If the room is poorly ventilated high concentrations of carbon monoxide accumulate rapidly.

The build-up of carbon monoxide in ice-skating rinks due to ice resurfacing machines is another common problem. In Seattle 15 children became ill after skating at an enclosed rink.[9] Because they had nausea and vomiting, food poisoning was suspected initially. After many patrons noted gassy odours, the propane-fueled ice resurfacing machine was examined and was found to produce high concentrations of carbon monoxide. The problem was compounded because children have higher rates of metabolism and of uptake of carbon monoxide, and the activity of skating increases their respiratory volume. A survey of other rinks in the Seattle area showed that this was a common problem. A program was instituted to educate rink owners and to encourage them to purchase carbon monoxide detectors. Improvement occurred in these rinks when the machines were run less frequently and for shorter periods, and when the rinks were better ventilated. The use of catalytic mufflers was recommended. A more dramatic episode was reported by Saslow and Clark[10] after 171 patrons in a sports arena manifested dizziness, nausea, tinnitus, disorientation, numbness of the feet and hands, blurred vision, vomiting and, in some cases, loss of consciousness. The source of the gas was traced to a broken exhaust pipe on a natural gas engine used in the ventilation system of the sports arena.

Although most cases of carbon monoxide poisoning result from incomplete combustion of carbonaceous fuels, an unusual source of carbon monoxide was described recently by Stewart and Hake.[11] Paint strippers, whose basic ingredient is methylene chloride, were noted to produce high concentrations of carbon monoxide in poorly ventilated rooms.[11]

Recently I saw a case of acute carbon monoxide poisoning in a high-school student who was working over a chafing dish heated by three cans of Sterno (manufactured by Colgate–Palmolive). The chafing dish was surrounded by aluminum foil except for one opening, where the food server stood. We obtained values of 1000 to 3000 parts per million (ppm) of carbon monoxide around this apparatus and values of 750 to 1000 ppm at the level of the food server's face. Her episode of unconsciousness was initially attributed to epilepsy. On investigating the case I found that all the girls who served at this table had had symptoms of carbon monoxide poisoning. Fortunately the

dining room was well ventilated and the university students were exposed to values of only 50 to 70 ppm while they were eating. (This case is reported in greater detail in this issue of the Journal, beginning on page 800).

Gilbert and Glaser[12] described a remarkable case in which the signs and symptoms of carbon monoxide poisoning were also thought to be due to epilepsy. The man had had repeated episodes of unconsciousness and personality change over a 4-year period due to carbon monoxide poisoning at his place of work.

As we become more aware of the risks of acute carbon monoxide poisoning, questions are being raised about the possible effects of low exposures over a long period. The relation of such exposure to vascular disease, atherosclerosis, myocardial infarction and recurrent angina pectoris is being assessed.[13-15] Uncertainty about the effects of long-term exposure to low concentrations of carbon monoxide has given rise to doubts about safety standards. In the past 50 ppm of carbon monoxide for 8 hours was the maximum allowable concentration. The United States Environmental Protection Agency has recommended 35 ppm for 1 hour or 9 ppm for 8 hours.[16] The objective of Environment Canada for quality of ambient air is an average concentration of 0 to 6 mg/m^3 over 8 hours or 0 to 15 mg/m^3 over 1 hour. Acceptable average concentrations are 6 to 15 mg/m^3 over 8 hours or 15 to 32 mg/m^3 over 1 hour. An acceptable occupational concentration is an average of 55 mg/m^3 over 8 hours or 440 mg/m^3 during an exposure of less than 15 minutes.

At a time when homes are being made airtight and when cheaper methods of heating are being sought, it is important that the public be made aware of the dangers of carbon monoxide poisoning. There should be wide public recognition of the fact that the burning of any fuel, whether in a fireplace or by a motor, requires adequate oxygenation and ventilation. Incomplete burning of any fuel will produce carbon monoxide.

T.J. MURRAY, MD, FRCP[C]
Chief of medicine
Camp Hill Hospital
Halifax, NS

References

1. SMITH JS, BRANDON S: Acute carbon monoxide poisoning — 3 years' experience in a defined population. *Postgrad Med J* 46: 65, 1970
2. STEWART RD: Proceedings: the effects of carbon monoxide on humans. *J Occup Med* 18: 304, 1976
3. ROOT WS: Carbon monoxide, in *Handbook of Physiology,* sec 3: *Respiration,* vol 2, FENN WO, RAHN H (eds), Am Physiol Soc, Baltimore, Williams & Wilkins, 1965, pp 1087-98
4. COBURN RF (ed): The biological effects of carbon monoxide. *Ann NY Acad Sci* 174: 1, 1970
5. MACMILLAN V: Cerebral carbohydrate metabolism during acute carbon monoxide intoxication. *Brain Res* 121: 271, 1977
6. MAUGH TH: Carbon monoxide: natural sources dwarf man's output. *Science* 177: 338, 1972
7. RADFORD EP: Proceedings: carbon monoxide and human health. *J Occup Med* 18: 310, 1976
8. WILSON FF, RICH TH, MESSMAN HC: The hazardous hibachi: carbon monoxide poisoning following use of charcoal. *JAMA* 221: 405, 1972
9. JOHNSON CJ, MORAN JC, PAINE SC, et al: Abatement of toxic levels of carbon monoxide in Seattle ice-skating rinks. *Am J Public Health* 65: 1087, 1975
10. SASLOW AR, CLARK PS: Carbon monoxide poisoning. Report of an outbreak involving 171 persons. *J Occup Med* 15: 490, 1973
11. STEWART RD, HAKE CL: Paint-remover hazard. *JAMA* 235: 398, 1976
12. GILBERT GJ, GLASER GH: Neurologic manifestations of chronic carbon monoxide poisoning. *N Engl J Med* 261: 1217, 1959
13. US National Research Council, committee on effects of atmospheric contaminants on human health and welfare: *Effects of Chronic Exposure to Low Levels of Carbon Monoxide on Human Health, Behavior, and Performance; a Report Prepared for the Environmental Studies Board of the National Academy of Sciences and National Academy of Engineering,* Washington, 1969
14. ANDERSON EW, ANDELMAN RJ, STRAUCH JM, et al: Effect of low-level carbon monoxide exposure on onset and duration of angina pectoris. A study of ten patients with ischemic heart disease. *Ann Intern Med* 79: 46, 1973
15. KJELDSEN K, THOMSEN HK, ASTRUP P: Effects of carbon monoxide on myocardium: ultrastructural changes in rabbits after moderate, chronic exposure. *Circ Res* 34: 339, 1974
16. Environmental Protection Agency. National primary and secondary ambient air quality standards and air pollution and control. *Federal Register* 36: 1501 (Jan 30), 1971