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*AJNR Am J Neuroradiol* 1999, 20 (2) 352-353
http://www.ajnr.org/content/20/2/352

*AJNR Am J Neuroradiol* 20:352–353, February 1999

**Technical Note**

# Exposure of Medical Personnel to Methylmethacrylate Vapor during Percutaneous Vertebroplasty

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**Summary: The occupational exposure to methylmethacrylate (MMA) vapor during percutaneous vertebroplasty was determined. During five vertebroplasty procedures, air-sampling pumps were attached to medical personnel. MMA vapor levels in the samples were then quantified using gas chromatography. The samples collected yielded MMA vapor levels of less than five parts per million (ppm). The MMA vapor concentrations measured were well below the recommended maximum exposure of 100 ppm over the course of an 8-hour workday.**

Percutaneous injection of polymethylmethacrylate (PMMA) cement into vertebral body compression fractures, a technique known as percutaneous vertebroplasty, has been recommended for pain relief and spine stabilization (1–5). Vertebroplasty has been used to treat pathologic compression fractures resulting from osteoporosis (1), metastases (2, 5), and hemangioma (4). The PMMA mixture used for vertebroplasty is prepared by the operator at the time of the procedure (1). Preparation of the PMMA mixture exposes the patient and the medical staff to methylmethacrylate (MMA) vapor, which, in high concentrations, can have toxic effects (6–12). We analyzed air samples obtained during vertebroplasty to determine if the MMA vapor levels were potentially hazardous.

## Methods

The technical aspects of the vertebroplasty procedure have been described previously (1). The PMMA was mixed on a workbench without the use of a fume hood or other vapor control device. The room air flow from the heating and cooling system was 22 air changes per hour. A total of approximately 20 mL of PMMA mixture was prepared and used as described previously (1). Air-sampling pumps were attached to the surgical gowns of two physician operators involved in mixing and injecting the PMMA mixture, yielding one sample from each physician. MMA vapors were drawn through air-sampler tubes containing porous XAD-2 resin. Samples were collected throughout the procedure at a rate of 100 $cm^3$/min. The duration of the procedure was approximately 1 hour. MMA vapor levels in the samples were then quantified using gas chromatography. Sampling and measurement techniques were performed as described previously (6).

## Results

The 10 samples obtained from the physician operators yielded MMA vapor levels below the detection capability of the measuring technique, which was 4.88 parts per million (ppm). The measured values represent exposures during a period of approximately 1 hour.

## Discussion

The exposure to MMA vapor concentration realized during percutaneous vertebroplasty ($< 5$ ppm) is well below the published recommended standard of 100 ppm (7). This recommended exposure level is a time-weighted average for an 8-hour workday. The measured values represent exposures during a period of approximately 1 hour. If each person's exposure is averaged over an 8-hour day, accounting for 7 hours of no exposure, the calculated time-weighted average exposure would be reduced by a factor of seven eighths. Under the conditions of this survey, the levels are, therefore, well within an acceptable range.

McLaughlin et al (8) also found occupational exposure of medical personnel to MMA to be at an acceptable level. These investigators measured MMA vapor concentrations achieved during total hip arthroplasty procedures in the operating room at 277 ppm immediately after the time of mixing, dropping exponentially thereafter, with concentrations of less than 10 ppm by 6 minutes after mixing. Our study did not measure the time course of MMA vapor exposure, as did the study by McLaughlin et al (8), but rather measured the average exposure over 1 hour. The amount of PMMA used in a hip arthroplasty is approximately 20 mL (9), which is the same amount used for a typical vertebroplasty.

PMMA is used to perform cranioplasty, to implant orthopedic prostheses, and to make artificial eyes and dentures. It is used in numerous products outside of medicine, including artificial fingernails, safety glass, and industrial coatings. Because of its widespread use, there has been great interest in environmental safety and toxicity related to exposure

Received July 14, 1997; accepted after revision June 22.

From the Department of Radiology (H.J.C., M.E.J., D.F.K., J.E.D.) and the Office of Environmental Health and Safety (D.N.E.), University of Virginia Health Sciences Center, Charlottesville.

Address reprint requests to Harry J. Cloft, MD, PhD, Department of Radiology, Box 170, University of Virginia Health Sciences Center, Charlottesville, VA 22908.

to MMA vapors and implantation of PMMA into humans. Acute exposure to extremely high levels of MMA vapor can cause liver necrosis, pulmonary edema, and pulmonary emphysema (10). Rats exposed to air containing 100 ppm of MMA for more than 1 hour developed interalveolar congestion and hemorrhage, as well as pulmonary vasodilatation and edema (11). Occupational exposure of medical personnel is well below the levels necessary to elicit these toxic effects. However, other less dramatic effects might occur. Dental students who were exposed to MMA vapor while preparing dentures complained of nausea and lack of appetite (12). MMA is known to be a potent allergenic sensitizer (13) and can cause local reactions with dermal exposure (14). It is also known to be a potential pulmonary toxin (11, 15); a study of industrial workers with chronic exposure to MMA vapor levels of 9 to 38.5 ppm found that 20% of the workers had a chronic cough, versus only 1% of workers in a control group with no MMA exposure (15). This study also found increased airway resistance as measured by spirometry in workers exposed to MMA vapor as compared with control subjects (15). A case of asthma induced by occupational exposure to MMA has also been reported (16).

An additional concern to workers exposed to chemical vapors is carcinogenicity. The carcinogenic potential of MMA vapors is not clearly defined. Chronic exposure of mice to MMA levels of 1000 ppm for 2 years was not found to induce an increased incidence of neoplasms (17). One study indicated that there may be an increase in mortality from colon and rectal cancer among industrial workers chronically exposed to uncontrolled levels of acrylate monomers (including MMA) (18). Workers exposed to acrylate monomers at legally controlled levels, however, had no increased mortality from colon and rectal cancer (18). Information acquired to date is inadequate to determine if MMA vapors might affect fertility or have teratogenic potential or other adverse effects on the fetus.

## Conclusion

MMA vapor levels to which medical personnel are exposed during percutaneous vertebroplasty are well below the level typically considered hazardous. However, it is important to note that some individuals may experience adverse effects, such as asthma, coughing, nausea, and decreased appetite, when exposed to levels typically considered to be within acceptable limits. At the levels of MMA vapor measured in our study, routine use of a fume hood is not necessary for MMA use in vertebroplasty, but a fume hood may be useful to reduce exposure of medical staff who are particularly sensitive to MMA vapor.

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