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Skin protection against methylmethacrylate

Ordinary surgical rubber gloves are penetrated by methylmethacrylate monomer (MMA) in less than 1 minute, as demonstrated by gas chromatographic measurements. A three-layered PVP glove, 0.07 mm thick – consisting of an outer layer of polyethylene, an intermediary layer of ethylene vinyl alcohol copolymer, and an inner layer of polyethylene – was impervious for 20 minutes, whereas a viton-butyl rubber glove, 0.27 mm thick, was impervious for 15 minutes.

The PVP glove is recommended to orthopedic surgeons, nurses, and other handling acrylic bone cements to avoid sensitization, and is especially recommended to persons with known contact allergy to MMA.

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Contact sensitization and toxic dermatitis to bone cement have been reported in dentists and dental laboratory technicians (Fisher 1956) and in orthopedic surgeous and nurses (Pegum and Medhurst 1971, Fries et al. 1975, Fisher 1979, Kassis et al. 1984). Surgical rubber gloves are not impervious to methylmethacrylate monomer (MMA) (Pegum & Medhurst 1971, Fries et al. 1975, Waegemaekers et al. 1983, Darre & Vedel 1984). It has been shown that multiple layers of ordinary surgical gloves tend to retard and reduce the diffusion of MMA proportionally to the number of layers, but the diffusion of MMA cannot be prevented in this way (Fries et al. 1975). A butyl rubber glove, 0.48 mm thick, proved to be impervious to MMA in vitro and prevented skin eruptions in 1 orthopedic nurse with known contact allergy to MMA (Darre & Vedel 1984, Kassis et al. 1984). However, because the glove thickness was inconvenient and the rather expensive butyl glove had to be sterilized after each use, we studied the permeability of MMA through alternative glove materials.

Materials and methods

Five different gloves were tested. One glove consisting of butyl rubber and viton, 0.27 mm thick, which was more flexible than the original butyl rubber glove. Another, the PVP glove, 0.07 mm thick, was constructed of three layers; an outer layer of polyethylene, an intermediary layer of ethylene vinyl alcohol copolymer and an inner layer of polyethylene. Both gloves were compared with three conventional surgical rubber gloves Latex (SemperMed®), Latex, brown (Perry Microptic®), and polystyrene-butadiene (Elastyren®). The viton-butyl glove was autoclavable at 121° C, whereas the other gloves needed sterilization by radiation.

The index finger was cut off from each glove and immersed in a glass container with concentrated MMA. The upper edge of the glove was turned over the edges of the container and the opening immediately closed air-tight. A 1 ml air sample was taken from the inner space of the glove finger with an air-tight syringe at fixed time intervals until significant amounts of MMA could be measured. Because MMA is a very light molecule, the distribution of MMA in the glove finger was uniform, and measurements taken from different parts of a glove finger showed similar MMA concentrations. All the experiments were conducted at 20.0±1° C. The experiments were repeated three times to find variations in the breakthrough time, if any.

Gas analyses were performed with a Gow Mac 552 gas chromatograph with chromosorb® 102, helium carrier (17 ml/min), injection temperature 185° C, detection temperature 210° C, column temperature 175° C, and a bridge current of 150 milliampere. The 1 ml air samples were injected into the gas chromatograph and the concentration of MMA was calculated. The detection limit was 0.2 volume ‰ MMA.

Results

The breakthrough times were constant during repeated measurements. In conventional surgical gloves the penetration of MMA was recorded during the first minute of immersion (Table 1). Disintegration of the rubber material was macroscopically evident after 3 minutes of immersion.

Table 1. Concentrations of methylmethacrylate monomer (MMA) in gas samples from the inner of gloves immersed in MMA for variable times and macroscopic changes in the glove material following immersion

Glove	Thickness (mm)	Immersion time (min), volume ‰ MMA						Macroscopic change
		1	2	15	20	30	40	
Latex	0.16	0.78	4.45					+
Perry Microptic	0.13	1.19	3.32					+
Elastyren	0.14	1.37	2.58					+
Vitonbutyl	0.27	0.00	0.00	0.00	2.40			(+)
PVP[a]	0.07	0.00	0.00	0.00	0.00	0.43	1.32	–

[a] An outer layer of polyethylene, an intermediary layer of ethylene vinyl alcohol copolymer, and an inner layer of polyethylene.

With the viton-butyl glove, MMA was detected after 20 minutes, and a slight change of the rubber material was observed as well. The gas concentration was rather abruptly increasing between 15 and 20 minutes. With the PVP glove, only small amounts of MMA were measured after 30 minutes. No macroscopic changes were observed, however, after 6 hours' immersion in concentrated MMA.

Discussion

The prevalence of contact eczema due to bone cements among orthopedic surgeons and nurses is unknown. MMA is a modest sensitizer as compared with other acrylic monomers, and the development of contact allergy may need several years of exposure (Van der Walle et al. 1982). Consequently, the orthopedic staff does not know if they are already on the way to develop a contact allergy.

Because the MMA has been shown to be the cause of all reported skin problems caused by bone cement (Fisher 1956, Pegum & Medhurst 1971, Fries et al. 1975, Fisher 1979, Kassis et al. 1984), concentrated MMA was used to detect the protective properties of the gloves tested. As the partial pressure of MMA in mixed bone cement is much less than in concentrated MMA, a glove able to withstand the concentrated MMA will provide a splendid protection.

The experiments were done at room temperature (20° C). The actual temperature inside the glove during work will of course be higher, but during these circumstances the MMA concentration inside the glove will be lower, as the MMA molecules tend to diffuse from the warmer towards the colder area. The polymerization of bone cement is an exothermic reaction. This increase in temperature will not influence the permeability of the gloves because the contact with the bone cement has stopped at the time of heat development.

Our investigation has demonstrated, like previous studies (Pegum & Medhurst 1971, Fries et al. 1975, Waegemaekers et al. 1983, Darre & Vedel 1984) that ordinary surgical gloves are incapable of preventing skin exposure to MMA. In less than 1 minute, MMA has penetrated the surgical rubber gloves examined.

The viton-butyl glove, 0.27 mm thick, prevented skin exposure for at least 20 minutes. The maximum time a surgeon or a nurse may be in contact with acrylic bone cement is much less.

The viton-butyl glove fits perfectly, but its high cost makes repeated use mandatory. Moreover, the penetration of acrylic monomers is known to continue after the direct contact has ceased (Fregert 1983). It also seems unadvisable to use the same glove repeatedly, as slight macroscopic changes in the glove material following 20 minutes' immersion in MMA have been demonstrated.

On the other hand, the PVP glove is fairly inexpensive, very thin, but is rather inelastic and the fit is not firm. It is easy to mix the acrylic cement while wearing this glove, however, because the sterilized PVP gloves can be put on over the usual surgical gloves. As soon as the mixing and handling of the cement is finished, the glove can be thrown away. For a better fit, the surgeon can put another pair of surgical gloves over the PVP gloves. When the insertion of the prosthesis is finished, the two outer gloves are thrown away.

References

Darre, E. & Vedel, P. (1984) Surgical rubber gloves impervious to methylmethacrylate monomer. *Acta Orthop. Scand.* **55**, 254–255.

Fisher, A. A. (1956) Allergic sensitization of the skin and oral mucosa to acrylic resin denture materials. *J. Prost. Dent.* **6**, 593–602.

Fisher, A. A. (1979) Paresthesia of the fingers accompanying dermatitis due to methylmethacrylate bone cement *Contact Derm.* **5**, 56–57.

Fregert, S. (1983) Occupational hazards of acrylate bone cement in orthopedic surgery. (Editorial). *Acta Orthop. Scand.* **54**, 787–789.

Fries, I. B., Fisher, A. A. & Salvati, E. A. (1975) Contact dermatitis in surgeons from methylmethacrylate bone cement. *J. Bone Joint Surg.* **57-A**, 547–549.

Kassis, V., Vedel, P. & Darre, E. (1984) Contact dermatitis to methylmethacrylate. *Contact Derm.* **11**, 26–28.

Pegum, J. S. & Medhurst, F. A. (1971) Contact dermatitis from penetration of rubber gloves by acrylic monomer. *Br. Med. J.* **2**, 141–143.

Waegemaekers, T. H., Seutter, E., den Arend, J. A. . & Malten, K. E. (1983) Permeability of surgeon's gloves to methylmethacrylate. *Acta Orthop. Scand.* **54**, 790–795.

Van der Walle, H. B., Klecak, G., Geleick, H. & Bensink, T. (1982) Sensitizing potential of 14 mono (meth) acrylates in the guinea pig. *Contact Derm.* **8**, 223–235.

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