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L H Monsein, G M Debrun and J R Chazaly

AJNR Am J Neuroradiol 1990, 11 (4) 663-664
http://www.ajnr.org/content/11/4/663.citation

Hydroxyethyl Methylacrylate and Latex Balloons

Lee H. Monsein,[1] Gerard M. Debrun, and Jacqueline R. Chazaly

Room-temperature vulcanizing silicone and homopolymers of 2-hydroxyethyl methacrylate (HEMA) have been used to permanently inflate detachable balloons [1]. HEMA is preferred over silicone because it is less viscous and is water soluble.

Goto et al. [2] described a commercially available (HEMA A, Interventional Therapeutics, S. San Francisco, CA) polymerizing substance that includes HEMA as the monomer, polyethylene glycol dimethacrylate (PEDGM) as the cross-linking agent, and hydrogen peroxide and ferrous ammonium sulfate as the curing agents. Complete solidification requires a concentration of at least 42% activated HEMA mixture. Double-lumen catheters or single-lumen catheter/vent tube systems provide this required concentration, even in small balloons.

A second HEMA mixture (HEMA B, Balt, Paris, France) has recently become available commercially. It also includes HEMA as the monomer, PEDGM as the cross-linker, and hydrogen peroxide and ferrous ammonium sulfate as the curing agents, although at different concentrations. We compared the two HEMA preparations in vitro.

Materials and Methods

HEMA A was prepared by adding 1 ml of a premixed solution of HEMA and PEDGM to 0.5 ml of 3% hydrogen peroxide and titrating with four or five drops of a solution of 50 mg ferrous ammonium sulfate in 1 ml nonionic distilled water (Table 1). Ten no. 9 Debrun latex balloons (Ingenor, Paris, France) were filled with 1 ml of HEMA.

Ten balloons were filled with HEMA B, which was prepared by combining a premixed solution of 2.45 ml HEMA and 0.05 ml PEDGM, 0.05 ml of 30% hydrogen peroxide, and 1.5 ml iohexol (200 mg/dl). This was titrated with approximately eight drops of 50 mg ferrous ammonium sulfate in 1 ml nonionic distilled water (Table 1).

All balloons were placed in fresh frozen plasma at 37°C. They were intermittently observed for up to 72 hr for signs of balloon degradation or rupture.

Results

One of the HEMA A balloons ruptured by 19 hr after curing. Another five ruptured and separated from the hardened HEMA by 48 hr (Fig. 1). The remaining four balloons were pitted—three with macroscopic holes (Fig. 2). All of the HEMA B balloons were intact at 48 hr (Fig. 3). None of them ruptured, fractured, or became pitted.

Discussion

Many centers are now treating cerebral aneurysms by the endovascular route with preservation of the parent artery [3]. Most use detachable latex or silicone balloons for occlusion of the aneurysmal sac.

Permanent inflation of the detachable balloon is desirable in order to prevent rupture, recanalization, or thromboembolism. This can be achieved by filling the balloon with a solidifying agent. Silicone and HEMA have been used for this purpose.

Anecdotal observations by other investigators (Berenstein A, Moret J, personal communication) of the rupture of latex balloons filled with HEMA led us to study the two commercially available preparations in vitro. Our preliminary tests suggested that iodine, silicone, and HEMA B did not cause degradation of latex or silicone balloons; however, HEMA A caused degradation of the latex but not the silicone balloons. The current study confirmed a difference in the compatibility of different preparations of HEMA and latex balloons.

It has been suggested that certain, possibly evaporable, components of HEMA, such as ether or chloroform, may be responsible for latex degradation. Exposing the HEMA and PEDGM mixture to room air would therefore theoretically reduce this problem. Our preliminary data suggest that this may reduce but not eliminate the problem.

TABLE 1: Composition of HEMA A and B

	HEMA A (ml)	HEMA B (ml)
HEMA/PEGDM	1.0	2.5*
H_2O_2	0.5 (3%)	0.05 (30%)
$FeNH_4SO_4$ (50 mg)	4–5 drops	8 drops
Iohexol (200 mg/dl)	—	1.5

Note.—HEMA = hydroxyethyl methylacrylate, PEGDM = polyethylene glycol dimethacrylate.

* 2.45 ml HEMA and 0.05 ml PEGDM.

Received September 23, 1989; revision requested November 9, 1989; revision received December 26, 1989; accepted December 26, 1989.

[1] All authors: Neuroradiology Division of the Russell H. Morgan Department of Radiology and Radiological Sciences, Meyer #8-140, Johns Hopkins Hospital, 600 N. Wolfe St., Baltimore, MD 21205. Address reprint requests to L. H. Monsein.

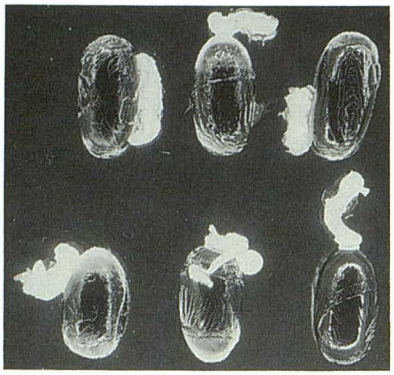

Fig. 1.—Rupture of latex balloons 48 hr after being filled with HEMA A.

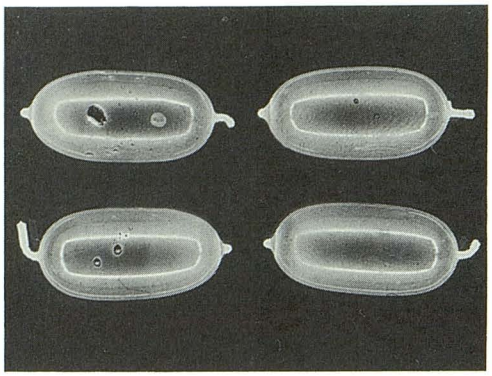

Fig. 2.—Degradation of latex balloons 48 hr after being filled with HEMA A.

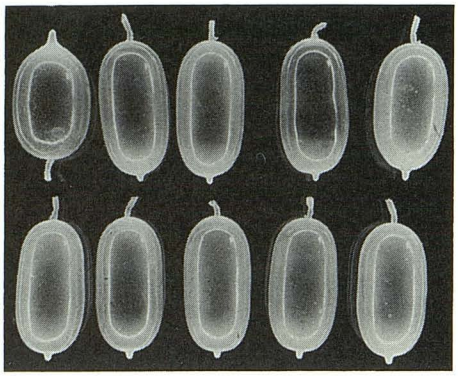

Fig. 3.—Intact latex balloons 48 hr after being filled with HEMA B.

One difference in the HEMA preparations is the amount and concentration of hydrogen peroxide. HEMA B utilizes one tenth the amount of hydrogen peroxide at 10 times the concentration of HEMA A. This should result in less loss of water from the balloon and therefore a more stable size and weight, which may have some affect on balloon integrity. In this regard we are currently determining the volume and composition changes that occur during and after curing with the different HEMA preparations.

The exact significance of this latex degradation is uncertain. After solidification, thromboembolism of the balloon fragments is a potential complication. There have been a few reported cases of rupture of a balloon before solidification (Berenstein A, Moret J, personal communication). Although we observed gross degradation of balloons only after solidification, we wonder if this effect could start on initial contact, thereby lowering the normal threshold for rupture of balloons during inflation. Additional stress on the aneurysm could promote rupture. Endothelialization and hemodynamics of the aneurysm may be different with the HEMA in direct contact with the circulation instead of with the surface of an intact balloon.

We recommend caution in selecting the type of polymerizing agent to be used with latex balloons in the endovascular treatment of cerebral aneurysms.

Addendum

Since the completion of this manuscript, the experiment was repeated with similar results with two additional batches of HEMA from the manufacturer of HEMA A. The batch reported in the article was obtained in July 1989. The two additional batches were obtained in 1986 (courtesy of Alan J. Fox) and January 1990, respectively.

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