EXPERIMENTAL STUDIES IN SURGERY OF SMALL BLOOD VESSELS

II. PATCHING OF ARTERIOTOMY USING A PLASTIC ADHESIVE*

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A NASTOMOSIS by suturing, patching, and shunting of small arteries and veins 4 mm. or less in external diameter carry a high incidence of failure because of constriction and thrombosis, as compared to vessels of larger diameter (5–6 mm. and larger). It is true that Seidenberg et al.12 reported excellent results by meticulous direct anastomosis of small arteries with sutures, using 7-0 braided silk.13 However, application of this technique to surgery of intracranial vessels presents additional difficulties, such as: (1) difference in structure of cerebral arteries as compared to extracerebral vessels, with less adventitia, reduced media, absent external elastic membrane, and minimal support by surrounding tissues; (2) the presence of perforating branches precluding rotation; (3) limitation of time of vascular occlusion (even with the use of hypothermia); and (4) lack of maneuverability. With a few exceptions,11,15 patency of the artery has been lost, or could not be re-established, following such attempts in man.8–11,14,15

For these reasons, laboratory studies have been under way for the past 3 years to develop a nonsuture method of anastomosing small vessels applicable to both arteries and veins and to the peculiar prerequisites of intracranial vascular surgery.

The possibility of using plastics as an adhesive material for purposes of vascular surgery was considered. After some trials, methyl 2-cyanoacrylate adhesive was employed (both as the monomer and as Eastman 910 Adhesive).‡ This report presents primarily the results of 85 arterial patches using this plastic adhesive; other technical applications of this method now under study are also mentioned.

(1) Properties of Cyanoacrylate Adhesive.

Eastman 910 Adhesive is a monomer, methyl 2-cyanoacrylate, with a thickening agent (to increase viscosity), plasticizer (to prevent embrittlement with ageing), and inhibitor (stabilizing agent) added. It forms strong bonds between a large number of materials in a few seconds to minutes. This bonding action occurs by an anionic mechanism of polymerization in which the liquid is converted to the solid state when a thin film of the adhesive is pressed between two adherents; it does not require heat, evaporation of a solvent by excessive pressure, or the addition of catalysts. The polymerization apparently is catalyzed by minute amounts of moisture or weak bases present on the adherent surfaces. It is believed that the adhesive performs both by molecular attraction on smooth surfaces (specific adhesion) and by mechanical grip action of the set adhesive on irregular and porous surfaces (mechanical adhesion). The material is of stable tempera-

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ture (up to 165°C.) and chemically resistant, with the exception of mild weakening in acid, alkali, and humid environment.

(2) Toxicity of Methyl 2-Cyanoacrylate (Eastman 910 Adhesive). Studies of toxicity to date have shown that Eastman 910 Adhesive is inert, relatively nontoxic, and nonsensitizing to skin. It may be slightly and transiently irritating to mucous membrane.

(3) Behavior of Eastman 910 Adhesive in Animal Tissues. Studies of the properties of Eastman 910 Adhesive in animal tissues have been carried out by Fassett. Subcutaneous injection of the monomer in the guinea pig caused polymerization at the site. The size of the mass produced diminished gradually and had nearly disappeared after a period of 3 months. Microscopic sections initially revealed a foreign-body reaction, with subsequent diminution of the cellular reactions; intense fibrosis did not result. Experience in our laboratory in dogs corroborates the absence of excessive reaction of tissue.

(4) Sterility of Eastman 910 Adhesive. Cultures of the monomer and of Eastman 910 Adhesive taken directly from the unsterilized original containers have been sterile. It is presumed that the compound is self-sterilizing, although it is not known as yet whether the growth of implanted bacteria would be suppressed. Wound infections have not occurred in these experiments using the adhesive from the original containers. However, sterilization electronically or by roentgen irradiation would seem desirable.

(5) Nonsuture Techniques in Surgery of Small Blood Vessels. Four basic techniques, using Eastman 910 Adhesive, are employed for vascular surgery, with the latter three still under development:

a. Patch of Arteriotomy (Figs. 1, 2 and 3). The artery (2–4 mm. in diameter) is exposed carefully, using procaine solution (2 per cent) to prevent spasm, and is denuded of adventitia. The artery is occluded by two small bull-dog clamps between which a 3–10 mm. longitudinal incision is made (in some instances a vessel wall 1–1.5 mm. in width was actually excised). The lumen of the vessel is irrigated with normal saline, removing all residual blood between the clamps. The vessel is flattened, elevated over a flat instrument, and carefully dried, using gauze sponges, bulb syringe, or air brush. An extremely small amount of Eastman 910 Adhesive (or monomer) is placed on the surface of the vessel surrounding the margins of the incision, avoiding entry of the material into the lumen. A previously prepared patch (either Nylon, crimped Dacron, Mersilene,* or autogenous vein, artery, or fascia) immediately is placed over the incision, and mild pressure is exerted to start polymerization; 2 minutes are allowed for setting. The clamps are removed simultaneously and free flow of blood is re-established immediately. Leakage usually does not occur with venous, arterial, and fascial patches, nor with pre-clotted Nylon, Mersilene, and Dacron material. With nonpre-clotted Nylon and Mersilene, there may be occasional leakage of

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![Fig. 1. Patch anastomosis described in text. In all drawings, free flow of blood is indicated by removal of clamps. Forceps are indicated for patching and eversion.](image-url)