NONSUTURE SEALING OF A DURAL SUBSTITUTE UTILIZING A PLASTIC ADHESIVE, METHYL 2-CYANOACRYLATE

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THREE basic purposes of the use of dural substitutes in neurosurgery are to prevent adhesions between brain and overlying soft tissue, to prevent leakage of cerebrospinal fluid, and to replace membrane affected by injury or disease.

Many synthetic plastics and fibers have been used as dural substitutes, including polythene film,1,2 Vinyon "N,"3,17 Orlon,4,10 and polyvinyl sponge.5 These agents have been applied with the use of a suturing technique to obtain a leakproof seal. Regardless of the type of dural substitute employed, the placement of sutures to ensure a watertight dam is often difficult and laborious, bringing with it the added hazard of a foreign-body reaction about the site of the sutures which may encourage the formation of meningo-cerebral adhesions.

During the past few years, synthetic plastic adhesives have been used in both experimental animals and humans for coating and reinforcement of intracranial aneurysms,16 closure of arterial incisions and blood-vessel anastomoses,4,11-14 closure of skin incisions,11 and anastomoses of small bowel.11 Inou and associates11 reported using methyl 2-cyanoacrylate monomer on humans for closure of skin incisions, closure of an intestinal fistula, and reinforcement of a gastrojejunostomy.

This report concerns the evaluation of a method to produce rapid, watertight sealing of a synthetic dural substitute, Teflon, by means of plastic adhesive, methyl 2-cyanoacrylate.‡

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‡ Obtained as Eastman 910 Monomer and supplied by Ethicon, Inc.

MATERIAL AND METHOD

Properties of Methyl 2-Cyanoacrylate.5,7 This adhesive monomer is produced by condensing formaldehyde with an alkyl cyanoacetate in the presence of a basic catalyst to yield first a poly (alkyl cyanoacrylate), the depolymerization of which yields the alkyl 2-cyanoacrylate. A thickening agent, a plasticizer, and an inhibitor are added to give it viscosity and to overcome embrittlement of the bond during aging. The material forms strong, rapidly setting bonds with a wide range of adherent combinations. The bonding occurs through a mechanism of anionic polymerization catalyzed by traces of water or other weak bases present on the adherend surfaces. The adhesive acts by its molecular attraction with smooth, dense surfaces (specific adhesion) and by the interlocking of set adhesive on irregular or porous surfaces (mechanical adhesion). A cured adhesive bond is stable to 165°C., and 24-hour bonds at 17°C. retained their initial high tensile strength. The material is chemically resistant, with weakening of the bond generally occurring in the presence of water at room temperature and in the presence of a weak alkali. The monomer has been found to be sterile,7,11 probably because of the cyanide radical in its molecular formula. The monomer sets up immediately, and only a small amount of pressure is necessary to achieve bonding.

Properties of the Dural Substitute. Teflon§ was used in this study because of its great inertness and because it incites less foreign-body reaction of tissue than other materials.

§ Supplied by U. S. Catheter and Rubber Company.
Harrison used Teflon in arterial and pericardial grafts and found less reaction, more rapid healing, a lower rate of thrombosis, and greater resistance to degradation than with Nylon, Dacron, Orlon, and Ivalon sponge. The Teflon used in this study was the white, purified type, 200 denier in size, 0.5 mm. in thickness, chain link in knit with 70 stitches per square-inch weave.

**Experimental Procedure.** For this study healthy mongrel dogs were used. Each animal was anesthetized with pentobarbital sodium, 30 mg. per kg. of body weight. All the neurosurgical procedures were carried out under sterile conditions. Hemostasis was carried out with electrocautery and the use of Gelfoam. The animals were divided into two groups, as follows.

**Group A.** Five adult mongrel dogs were used. In 3 dogs a left occipitoparietal craniotomy was performed; a free bone flap was employed. The exposed dura mater was incised and reflected, and the entire left occipital lobe was resected surgically. The mid-portion of the two dural edges were brought together and approximated with one 6-0 dural silk suture, leaving two dural defects each 1.5 cm. in diameter. These defects were covered with two pieces of Teflon which was impregnated on both sides with methyl 2-cyanoacrylate. The adhesive-impregnated patches were lightly pressed down along the dural borders for about 30 sec. or until a good seal was obtained. In each case the edges of the patch securely adhered to the dura mater. The bone flap was replaced and the incision was closed in layers. Postoperatively, all animals received 300,000 units of procaine penicillin intramuscularly.

In 2 dogs the same procedure was performed as above except that only a portion of the occipital cortex and overlying dura mater, measuring 2.0 cm. in diameter, was resected. A Teflon patch impregnated with methyl 2-cyanoacrylate on both sides was then placed over the dural defect.

**Group B.** In 3 animals a left occipitoparietal craniotomy was performed; a free bone flap was employed. A circular portion of dura mater, 2.5 cm. in diameter, was removed without disturbing the underlying cortex, and a circular Teflon patch impregnated on both sides with methyl 2-cyanoacrylate was placed over the dural defect, the edges of the patch overlapping the dural edges. The adhesive-impregnated patches were anchored securely to the dura mater in all cases. The bone flap was replaced and the incision was closed in layers. Postoperatively, all animals received 300,000 units of procaine penicillin intramuscularly.

The animals in both groups were observed for 6 weeks, after which they were sacrificed. Tissue blocks were cut to include the edge of the lobectomy wound, neomembrane, normal dura mater, and underlying brain. After embedding in paraffin, histologic sections were prepared with hematoxylin-eosin, Luxol fast blue counterstained with cresyl-violet, Mallory's phospho-tungstic acid hematoxylin, Mallory-Heidenhain connective-tissue stain, and Verhoeff's elastic-tissue stain counterstained with van Gieson's stain. Gram's stain and Perl's reaction for iron were also used when indicated. Bodian's method for axons was used on frozen sections.

**RESULTS**

Clinically, all animals survived the experimental procedure. No evidence of convulsive disorders appeared at any time, and there was no evidence of cerebrospinal-fluid leakage. The following are the pathologic findings for each group.

**Group A. (Total or Partial Occipital Lobectomy with Placement of Dural Substitute.)** There were 5 animals in this group. Since the findings at postmortem examination were similar they will be discussed as a group.

**Gross Examination.** Before the animals were sacrificed, the operative site showed evidence of advanced healing, without infection. The calvarium and the parietal, temporal, and occipital lobes on the side of the operative procedure were removed. The specimen was placed immediately in 10 per cent formalin and examined 2 weeks later. At this time the bone flap was removed, exposing the underlying Teflon patch. The patch was slightly adherent to the edges of the craniotomy wound, with numerous fine adhesions to the underlying neomembrane. When the Teflon patch was lifted out of the operative field, the neomembrane was visualized easily. The membrane was grayish-white in color. The membrane was firmly attached to the edges of the craniotomy wound. The surrounding normal dura mater and the neomembrane were then stripped in continuity from the undersurface of the calvarium, with care being taken not to disturb the relationship between the neomembrane and the underlying brain.

After the brain, meninges, and neomembrane were removed intact from the calvarium, it was noted that the neomembrane