An Experimental Study of the Effects of a Plastic Adhesive, Methyl 2-Cyanoacrylate Monomer (M 2 C-1) in Various Tissues*

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Methyl 2-C-1 has been under investigation as a tissue adhesive for several years. It is a clear, mobile liquid. It is easily pressed between two surfaces. No heat, excessive pressure, addition of solvent, or catalyst is required for polymerisation. Bonding occurs through a mechanism of anionic polymerisation aided by traces of water; the adhesive acts by its molecular attraction (specific adhesion) and by the interlocking of the set adhesive on irregular surfaces (mechanical adhesion).

Since 1960, a number of investigators have studied the physical and clinical properties of this material, and breaches in the continuity of a variety of tissues that have been repaired with it. Seventy references had been collected and reviewed up to November 1964. Scrutiny of these papers, which are primarily laboratory and animal studies with only a few clinical reports, suggests that most of the authors are favourably impressed with M 2 C-1 as a glue; to date only 3 papers have been noted where caution was advised in its use. Not all the references are to the use of the pure monomer; various allied preparations containing inhibitors and plasticisers have been used, but today are not recommended for biological use.

Ten years ago, a method of investing intracranial aneurysms with self-curing methyl methacrylate was described by one of the present authors. In 1958, a report of 15 cases was published and recently, further information on 30 cases was presented. Amongst other theoretical criticisms of the use of methyl methacrylate, it was hydrophobic and thus never adhered to the tissues. There was a possibility (never encountered in practice) that in cases of total investment, rupture of the aneurysmal sac might result in tamponade of the sac and parent vessel within the acrylic shell. In an endeavour to overcome this objection and achieve a 'meld' between the sac wall and the investment, samples of M 2 C-1 were eventually obtained from Ethicon in 1963. The purpose of this paper is to present the results of experimental application of minute quantities of this monomer to a variety of tissues.

Method

Male and female cats whose weights varied from 2 to 2½ kilograms were used. All were anaesthetised with Pentobarbitone sodium (Nembutal) 35 mg./kg. of body weight. During the early stages of the study, M 2 C-1 was used from a 15 cc. bottle. More recently, sterile 1 ml. tubes have been used; this eliminated our original concern regarding deterioration of unused material in the bulk containers. Aseptic technique was maintained throughout the procedure.

Group 1(a). Surface of the brain. Thirteen cats were subjected to bilateral craniectomy exposing the lateral supra and ecto sylvian gyri. The dura mater was incised; the resultant defect was closed by a free fascial graft, coated with a small quantity of M 2 C-1 and light pressure applied. Saline was used on the contralateral side as a control.
The wounds were closed by single layer skin sutures. The animals were sacrificed at periods varying from 3 days to 8 weeks. The brain and dura in relation to the craniectomy were removed in one piece and fixed in 10 per cent formalin for 2 weeks. After brain cutting, tissue blocks were cut, embedded in paraffin and stained routinely with Weigert’s haematoxylin and eosin for cell detail, methasol fast blue to show myelin, phosphotungstic acid haematoxylin or Holzer’s stain to show gliosis, and Gros-Bielschowsky silver stain to show neurofibrils.

Results. All animals survived the experimental procedure. There was no evidence of infection, epilepsy, cerebrospinal fluid leak, or neurological deficit. At brain cutting the fascial graft was adherent to the dura, and the brain was adherent at the gap in dural continuity (Fig. 1). Coronal sections through graft, dura and brain were made and processed as above.

In most cases the graft was surviving; in places between it and the dura there were pools of refractile M 2 C-1, always closely surrounded by a zone of fibrin. Around the fibrin, a zone of nuclear debris and fragmenting polymorphs was present (Fig. 2); these changes persisted for at least 7 weeks. Beyond this layer a granulomatous healing reaction with macrophages, fibroblasts, new collagen and capillaries was found which in the later specimens became mature fibrous tissue.

At the dural gap, the new scar tissue extended through and was adherent to the pia arachnoid. Here the surface layers of the cortex showed a small amount of reactive gliosis (Fig. 3), but no loss of neurones (Fig. 1), and only occasional nerve cells showed ischaemic changes. In very early specimens there was some oedema of the outer 2 layers of the cortex, but this did not persist.

Examination of the control slides revealed relatively minor changes with some later fibrosis of dura and arachnoid.

Group 1(b). Within the brain. In 5 other cats, after making a breach in dural continuity and incising the arachnoid, a track approximately 2 cm. long was made vertically into the brain with a wooden applicator stick, the end being smoothly pointed. On one side monomer was applied, while on the other side normal saline was used as a control.

These animals were sacrificed at periods varying from 2 to 8 weeks, and the brains fixed and sectioned.

Results. All specimens showed brisk polymorphonuclear reaction along both tracks, but on the side of M 2 C-1 application there was neuronal death extending for a distance beyond the track which showed inflammatory reaction. Later specimens showed microglial macrophage collections and reactive gliosis along the track which extended through pia arachnoid to form an adhesion