THE REACTION OF CEREBRAL TISSUE TO SILVER, TANTALUM, AND ZIRCONIUM

A DISCUSSION OF THE USE OF THESE METALS FOR HEMOSTATIC BRAIN CLIPS*

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Since Harvey Cushing in 1911 introduced the use of the silver clip for hemostasis in neurosurgery, two important contributions have appeared. The first was McKenzie’s modification, using silver ribbon, easily removed from a magazine holder by a clip forceps. The second contribution was Pudenz’s experimental work in 1942, in which he demonstrated an intense inflammatory reaction in both nervous tissue and meninges when silver strips were inserted in the brain of cats. He showed that tantalum caused a minimal investment by connective tissue and/or neuroglia fibrils without the characteristic foreign body reaction. As a result of Pudenz’s work tantalum clips were substituted for silver clips for clinical use at the Montreal Neurological Institute.

In spite of this work many surgeons continue to use silver clips. It is the purpose of this experimental study to evaluate the reaction of a new metal, zirconium, in the brain of dogs and to compare this reaction to that produced by silver and tantalum.

Zirconium, like tantalum, is an inert element with very similar physical and chemical properties.

EXPERIMENTAL METHODS

The same technique as described in the previous paper, “The Repair of Cranial Defects with Zirconium” (see page 340 of this Journal), was used, except that 4 trephine holes were made, 2 in each parietal bone. A cruciate incision was made in the dura, and an avascular region of the brain was selected for insertion of the metallic strips. Pieces of silver, tantalum, and zirconium ribbon, 0.725 mm. wide and 0.325 mm. thick, were angulated to 90° so that the long arm measured 1.0 cm. and the short arm 0.3 cm. The 3 pieces were identical in each dog but varied slightly between dogs. The tips of the strips were pointed to cause less trauma. The longer arm of the metallic strips was inserted perpendicularly into the cerebral hemisphere, the shorter arm lying in contact with the pia arachnoid. The dural flaps were replaced but not sutured. The muscles, galea and skin were sutured and a dry dressing applied.

Seven dogs were used for this study. They were killed on the 8th, 13th, 25th, 29th, 75th, 89th and 97th days. In order to obtain adequate fixation of the brain in situ, the dogs were anesthetized with intravenous nembutal and the carotids perfused with physiological saline solution followed by 10 per cent formaldehyde solution. Immediately following this the skull was rongeured and the brain removed without disturbing the metal implants and placed in 10 per cent formaldehyde solution.

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When the brain was properly hardened, the dura was reflected from the cortical surface and the site of strip implantation examined for reaction. The strips were then carefully withdrawn from the brain. Blocks of cerebral tissue for microscopic study were cut in a plane allowing examination of the tract of the metal in cross section.

Paraffin sections, 5μ in thickness, were stained by the hematoxylin and eosin, toluidine blue, Masson's trichrome and Mallory's phosphotungstic acid hematoxylin methods.

RESULTS

Gross Findings.—The meningeal arm of the silver strip was invariably imbedded in a mass of white fibrous tissue. In most cases this was firmly bound to the overlying dura. In cross section the tract left by the silver strip showed an irregular margin with brownish discoloration of the surrounding brain and in a few cases frank necrosis (Fig. 1c). After 13 days a definite fibrous connective-tissue capsule was recognizable which became more definite in the later stages.

Tantalum strips provoked only minimal reaction (Fig. 1a). The meningeal reaction was slight, and in cross section the hole was sharply outlined with no staining of the brain. The only evidence of a connective-tissue capsule was in the dog killed on the 89th day.

Zirconium presented the same minimal reaction as tantalum except for 2 dogs killed on the 13th and 89th days in which there was slight brownish pigmentation of the surrounding brain. However, the margins of the holes were sharp, and there was no evidence of necrosis (Fig. 1b).

The silver strips were discolored in the later stages whereas neither the tantalum nor zirconium strips changed in color.

Microscopic Findings.—In the early, as

Fig. 1. Late gross reaction. Cortex a, b, and c from the same dog at 75 days. a, Tantalum; b, Zirconium; c, Silver. There is a wide zone of discoloration evident in the case of the silver, and negligible gross reaction to both zirconium and tantalum. The site of the zirconium pin is the oval, punched-out area. Hematoxylin and eosin, X5.