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SURGICAL IMPLANTATION OF EEG ELECTRODES IN THE DOG

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April 1975

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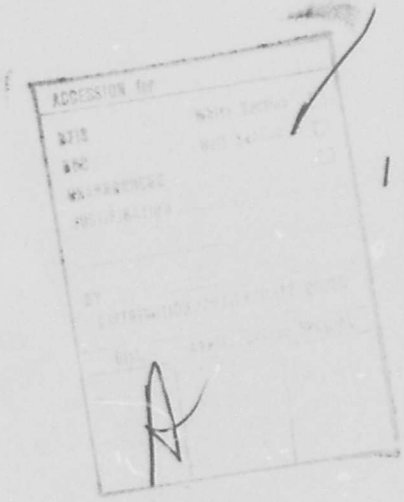

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A simple surgical technique for implanting chronic electroencephalographic electrodes in the skull of the dog was devised to obtain frequent electroencephalograms (EEG) from the unsedated and unanesthetized animal. The technique utilized orthopedic screws as the implant electrodes and for securing the recording assembly over the frontal sinus. The electrode assemblies have been tolerated very well for up to10 months in 17 of 20 dogs and have given reliable and very satisfactory EEG recordings, free of artifacts, in all animals, with a minimum use of physical restraint.

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PREFACE

The work described in this report was authorized under Project/Task 762718AD2104, Medical Effects of Chemical Agents; Animal Studies Related to Chemical Agents. This work was started in February 1974 and is still in process.

In conducting the research described in this report, the investigator adhered to the "Guide for the Care and Use of Laboratory Animals" as promulgated by the Committee on Revision of the Guide for Laboratory Animal Facilities and Care of the Institute of Laboratory Animal Resources, National Research Council.

Names of commercial manufacturers and trade names are provided for identification only and inclusion does not imply endorsement by the United States Army.

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SURGICAL IMPLANTATION OF EEG ELECTRODES IN THE DOG

I. INTRODUCTION.

Numerous methods have been devised for monitoring brain function in laboratory animals. Of these methods, the electroencephalogram utilizing scalp or depth electrodes has been suggested to best reflect cortical activity. Many ways to chronically implant depth electrodes into predetermined sites of the brain by stereotaxic means in the rodent, primate, canine, and feline species have been described.[1-7] Our basic need, however, was to develop a simple procedure for surgically implanting electrodes in the dog which would allow *frequent* periodic measurement of cortical activity in the unanesthetized and unsedated animal. For our purposes, scalp electrodes were found to be ineffectual due to artifacts produced by eye, ear, and head movements in the unanesthetized animal. The EEG technique described by others to evaluate clinical neurological cases did not meet our needs entirely.[8-11] Chemical sedation was not utilized since we wished to evaluate the central nervous system's reaction to certain drugs. For these reasons, a series of cortical electrodes was surgically implanted in the skull to allow for the measurement of electrical activity of the brain immediately adjacent to the dura.

II. MATERIAL AND METHODS.

Twenty dogs, weighing from 7 to 9 kilograms, underwent surgical implantation. Preliminary physical examinations as well as electrocardiographic, respiratory, hematological, and blood chemistry studies indicated that all the dogs were in apparent good health.

The cranial implant itself consisted of a 9-pin, female, plastic connector* with 0.008-inch Teflon-coated stainless-steel wire** soldered to each individual brass pin. A layer of epoxy glue† was used to support and seal the pins and wire to the connector. Varying lengths of wire were used in order to match as closely as possible the distance from the connector to each specific cranial electrode. A stainless-steel concave washer was spot-welded to the other end of the stainless-steel wire. The washer was fabricated so its concave surface closely matched the ventral surface of the orthopedic screw used as the cranial electrode. When assembled, the washer and screw form a stable electrical contact that can be implanted in the skull with minimum difficulty. The stainless-steel orthopedic screws used as electrodes were 2.7 mm in diameter and 6.0 mm in length.‡ A stainless-steel spacer with a 7.0-mm outside diameter and a 5.0-mm inside diameter, 1.0 mm thick, and 3.0 mm deep, was used to elevate the plastic connector from the skull surface. These spacers and the stainless-steel concave washers were fabricated in our laboratory's instrument shop.

Surgical Procedure.

The animal is preoperatively medicated with atropine sulfate (0.05 mg/kg) and acepromazine maleate§ (0.80 mg/kg) and is anesthetized with thiamyl sodium§§ at a dose of 17.5 mg/kg. Endotracheal intubation is established and the animal is maintained with 1% halothane‖ in a mixture of 3:1 nitrous oxide:oxygen. The dog is placed in ventral recumbency and the skin of the dorsal cranium is aseptically prepared for surgery.

An incision is made on the midline of the dorsal cranium extending from the external occipital protuberance anteriorly to the level of the medial canthi of the eyes. The superficial temporal fascia is bisected as are the interscutularis and frontalis muscles on the dorsal midline of the cranium. These structures are reflected laterally which reveals the glistening fascia of the temporalis muscle arising from the external sagittal crest medially.

An incision is made through the temporalis muscle from the external occipital protuberance, anteriorly to the external frontal crest keeping 0.5 cm lateral to the external sagittal crest. This 0.5-cm flap of tissue allows suturing of the temporalis muscle to its original position after the electrodes have been implanted. A periosteal elevator is used to clear the temporal fossa of tissue by reflecting the transected temporalis muscle laterally and ventrally.

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* Amphenol Series 223 connector assembly, distributed by Allied Electronics, Chicago, Illinois.

** Medwire Corporation, Mount Vernon, New York.

† Epoxy glue, Type 347, distributed by Allied Electronics, Chicago, Illinois.

‡ ASIF orthopedic equipment, Smith, Kline Surgical Specialties, Philadelphia, Pennsylvania.

§ Acepromazine maleate, Ayerst Laboratories, New York, New York.

§§ Surital, Parke, Davis & Co., Detroit, Michigan.

‖ Fluotane, Ayerst Laboratories, New York, New York.

The temporal fossa is now ready for implantation of the cranial electrodes. Seven electrodes were originally implanted but it was found that nine produced a better EEG recording. These include four electrode placements in the temporal fossa on each side of the skull and one midline ground electrode (figure 1). A recording electrode is implanted on both sides of the cranium in each of the following locations: the frontal area, the supratemporal area, and the mid- and rear-parietal areas. The ground electrode is implanted close to the dorsal midline of the skull caudal to the frontal sinus. The electrodes are placed visually, as accurately as possible, without using stereotaxic apparatus. The electrodes for the other side of the skull are implanted in the same manner with the specific intent of placing them so they will be mirror images of their counterparts.

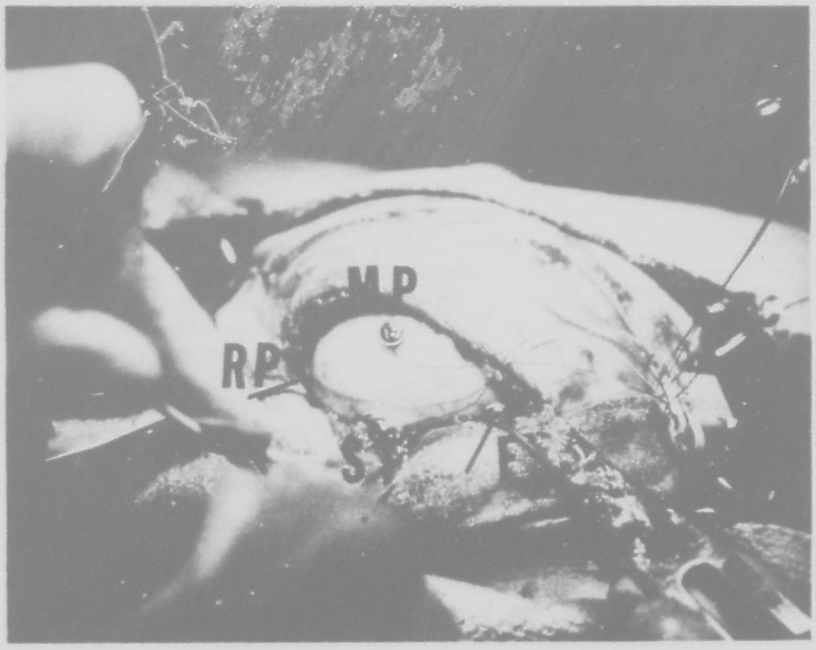

Figure 1. Temporalis Muscle with Cranial Electrodes Implanted in Temporal Fossa

Locations are as follows: (F) frontal, (ST) supratemporal, (MP) mid-parietal, (RP) rear-parietal.

The electrodes are placed by drilling 2.0-mm holes through the skull without penetrating the dura and tapping these holes with the 2.7-mm bone tap. The stainless-steel concave washer attached to the connector assembly is placed over the tapped hole and the electrodes are screwed into place.

After placement of the electrodes on one side of the cranium, the surface of the temporal fossa is rinsed with saline, and periosteal hemorrhage is controlled with cautery. To insulate each electrode and form a better contact with the skull, a small amount of dental acrylic* is placed over each electrode. The temporalis muscle is then sutured to the 0.5-cm flap on its medial origin at the external sagittal crest with 3-0 chromic gut using a simple-continuous suture pattern. The four leads are allowed to exit the incision in a medial direction to avoid any sharp bend in the wire.

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* Yates flash acrylic, Yates Dental Products, Chicago, Illinois.

After performing the same surgical procedure on the other side of the cranium, the electrical connector is fitted to an area on the dorsal midline of the skull directly over the lateral part of the frontal sinus. Any remaining fascia and periosteum are reflected away from the location where the connector will be placed. This tissue-free area should extend at least 2 to 3 centimeters caudally and anteriorly from the connector assembly. Periosteal hemorrhage is again controlled by cautery, and the area is rinsed with sterile saline. A 2.0-mm hole is drilled and tapped over the frontal sinus for both of the electrical connector's mounting screws. The screws used are 2.7 mm in diameter and 12 mm in length. The 3.0-mm stainless-steel spacers are placed between the skull and the electrical connector so the whole assembly will be elevated from the skin surface when completed. The connector is mounted very carefully so as tight a fit as possible exists between the skull and the connector assembly (figure 2).

Figure 2. Electrodes and Electrode Assembly Implanted and Temporal Muscles Sutured to Their Origins

Dental acrylic is now applied so it extends as evenly as possible around the connector assembly forming a bond between the connector and the skull surface. All roughened edges of acrylic are smoothed off as carefully as possible to reduce any tissue irritation after closure is accomplished (figure 3). The assembly is then allowed to harden sufficiently to permit the drilling of two holes through the acrylic, caudal to the connector assembly, and into the frontal sinus. The initial "pilot" hole is drilled using a 2.0-mm bit. Then a 3.5-mm bit is used to enlarge the hole in the acrylic but not extend it into the bony surface. This is done to create a "lag screw" effect when the connector assembly is drawn tight against the skull's surface.[12] The hole into the frontal sinus is tapped for a 2.7-mm stainless steel orthopedic screw, and then a 10-mm or 12-mm screw is driven through the dental acrylic into the skull to supply more support for the connector assembly.

Figure 3. Dental Acrylic Applied to Electrode Assembly

The fascia is sutured avoiding any "dead space" formation using 3-0 chromic gut in a simple-interrupted pattern. A simple-continuous pattern using 3-0 chromic gut is used in the dermal layer to bring the skin into apposition. Transverse skin incisions are made at the level of the connector assembly to allow for better closure at this site (figure 4). Nonabsorbable suture material* in a simple-interrupted pattern is used to close the skin. The female plastic connector with the electrical contacts is protected by inserting the appropriate male plug. Electroencephalograms are run on all preparations immediately following the surgical procedure and satisfactory recordings have been obtained in all cases.

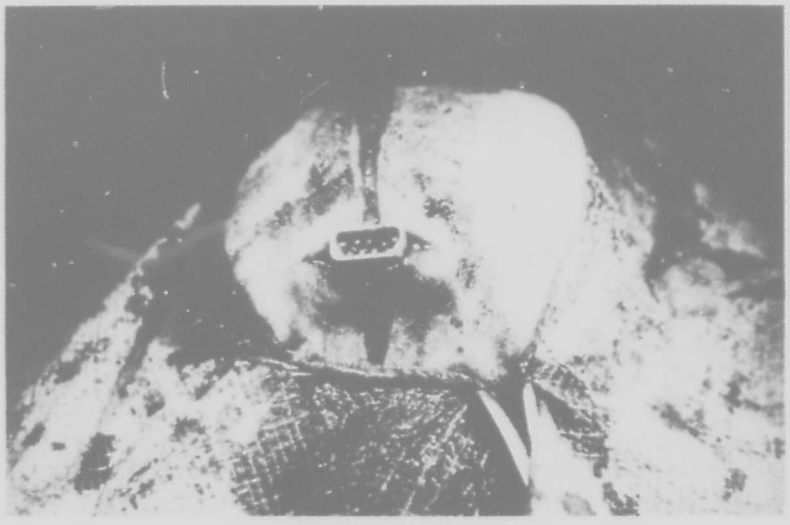

Figure 4. Transverse Incisions Made to Allow for Skin Closure Around the Implant Assembly

Postoperative care consists of treating the implant area daily with an antibiotic ointment (bacitracin and neomycin) after cleaning the area thoroughly with hydrogen peroxide. Infection of the implant site has not been a problem during the postoperative period. If there seems to be an excessive amount of exudate, the area is cultured and antibiotic sensitivity testing is performed; appropriate antibiotic therapy is then instituted. Sutures are removed 10 days after surgery, and, by the fourth to sixth week, the implant sites have healed with very little inflammatory reaction evident (figure 5).

Figure 5. Little Inflammatory Reaction Seen Six Weeks Postoperatively

III. DISCUSSION.

After a 10-month observation period, one dog was euthanatized to determine the pathological effects of the chronic implant. Necropsy and histopathologic results revealed that there were fibrotic adhesions between the tip of the implant screw and the dura matter, but no cortical changes had occurred.

Three of the animals that exhibited hyperexcitable behavior during the selection process loosened their implants after 4 months; the implants were removed to avoid any extensive infection. A dog that does exhibit intractable behavior should probably be avoided when selecting experimental subjects since trauma to the electrode assembly will cause abscessation and rejection.

We found that this surgical implant procedure satisfied our need for an EEG recording that could be run frequently in unanesthetized and unsedated animals with a minimum of artifact due to head movement. The surgical procedure is uncomplicated and takes little time to perform, and the experimental animals have tolerated the electrode assemblies very well for up to 10 months.

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* Vetafil Bengen, S. Jackson, Inc., Washington, D. C.

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