EXPERIMENTAL STUDIES OF THE EFFECT OF COAGULATING CURRENTS* UPON THE BRAIN
WHEN APPLIED TO THE INTACT DURA AND DIRECTLY ON THE CORTEX

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A fundamental problem in surgery of the nervous system is the control of bleeding, and a basic method of hemostasis in neurosurgery is the coagulating current of the surgical diathermy. Diathermy machines for medical and surgical use are based on the observation of d’Arsonval\(^1\) that alternating currents ceased to stimulate at very high frequencies and that the only apparent effect was the production of heat. By variations in character and manner of application, three tissue effects, which have surgical applications, are produced by diathermy currents: coagulation, cutting and desiccation.

The first surgical diathermy was constructed by Doyen\(^9\) and utilized the original circuit of d’Arsonval; it generated a very damped, high frequency current. Such a current produces a coagulation necrosis of tissue with complete cellular disruption to a depth dependent on the strength of current and duration of flow. It effects hemostasis by shrinkage of blood vessels and formation of an occluding coagulation.

Clark\(^3\) originated the technique of electrosiccation, which is produced by placing the active electrode at such a distance from the tissue that sparks pass across the gap. This causes a superficial layer of dehydrated tissue; the effect seems to be a lesser degree of the coagulation process.

The cutting effect is produced by an undamped, high frequency current; it was first perfected by Wyeth.\(^21\) With this current, the tissues separate before the electrode, producing an actual incision and little or no hemostasis.

Bovie\(^4\) devised a surgical diathermy in which the cutting and coagulating currents could be combined and incisions could be made with adequate control of hemorrhage. This was the instrument used by Cushing\(^7\) when he, in 1927, introduced “electro-surgery” into neurosurgery as an adjunct in the removal of the more inaccessible meningiomas. This machine was accepted as a basic advance in neurosurgery, and its use was quickly extended into all phases of neurosurgery with an emphasis on the hemostatic effect of the coagulating current.

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It soon became apparent that use on the skin of even the cutting current was inconsistent with primary healing, but little reference to its harmful effects on nervous tissue is to be found. Moore and associates demonstrated in this clinic that abnormal areas of nervous tissue (especially tumors) are usually stained by the dye fluorescein in contradistinction to the normal brain tissue, which is not stained. The identification of abnormal tissue was proved to be so reliable with the fluorescein technique that it is used routinely when the possibility exists of encountering tumor or abscess at craniotomy. Subsequently, it was noted by one of us (L.A.F.) that the dye had stained a small area of cortex underlying a site of dural coagulation. This observation has been confirmed in subsequent craniotomies.

The present report deals with the results of animal investigations into the characteristics of changes produced in the brain by the coagulating current as demonstrated by the fluorescein technique.

METHODS AND MATERIALS

The animals used were mongrel dogs and stock rabbits. Under sodium pentobarbital anesthesia, the dura over the cerebral hemispheres was exposed through a trephine opening or more extensive craniectomy. Every effort was made to maintain the integrity of the dura and to prevent trauma to the underlying cortex. In acute experiments the surgery was done merely under “clean” conditions; otherwise, strict operating room aseptic technique was maintained.

Coagulation current was applied with the ball point electrode of a spark-gap, surgical diathermy.* The inactive, plate electrode was placed on the shaved hind limb with saline to insure an efficient contact. At times a radio-frequency ammeter was placed directly in the circuit of the active electrode and readings were taken during coagulation.

In most animals the electrode was gently applied to the intact dura. Coagulations were done for measured time intervals at varying dial settings. In studies to determine the appearance time of the fluorescence it was necessary to reflect a dural flap and coagulate the cortex directly. Control animals underwent the same procedure except that the current was not turned on.

Examination of the coagulated areas was carried out under ultraviolet light,† after the injection of fluorescein. All studies of the appearance time and ancillary examinations were done on living animals. For the remaining studies, the animals were sacrificed by cardioseccion after injection of the dye; then, the brain was removed as a whole and examined.

Pathological sections were taken of representative areas and prepared with hematoxylin and eosin, Weil, and Nissl stains.

RESULTS OF COAGULATION STUDIES

Preliminary studies were done to determine the influence of the current level (as determined by dial settings), and the time interval of application

* Manufactured by Liebel-Flarsheim Company, Cincinnati. (Improved Davis-Bovie machine.)
† CH-4 mercury vapor lamp with Wood’s filter.