THE USE OF TANTALUM FOIL IN THE SUBDURAL SPACE

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The neurosurgical management of wounds of the central and peripheral nervous system sustained in modern warfare has been considerably facilitated by the introduction of tantalum. Its physical properties and inertness when in contact with body tissues have allowed its application in numerous forms, viz. plate, foil, wire and ribbon. Utilizing these different preparations, it has been possible to successfully repair cranial defects, secure hemostasis, perform accurate nerve suture and prevent postoperative adhesions (subdurally to avoid meningocerebral cicatrices; in the vicinity of peripheral nerve anastomoses and neurolyses; and extradurally in the spinal canal following disc surgery). In this communication, we are particularly interested in reporting our experiences following the use of tantalum foil subdurally in the prevention of post-traumatic and postoperative sequelae.

The high incidence of convulsions following gunshot wounds of the head with dural penetration is well known. Many of these are undoubtedly due to the formation of a meningocerebral cicatrix. Prevention of the latter, therefore, is of extreme practical importance. Pudenz and Odom have recently reviewed the literature and presented their experimental results on the various materials that are available for this purpose. These included the resorbable membranes (amnioplastin, Cargile and insulitoic membranes, films of 5 per cent polyvinyl alcohol) and tantalum foil. The latter, particularly, evoked only a very minimal connective-tissue and inflammatory reaction with only slight encapsulation. Attachment was noted only along the margins of the capsule. These observations were made from a study of six experimental animals over a period of from 10 to 143 days.

Delarue, Linell and McKenzie, on the contrary, do not advise the use of foil subdurally in head injuries with cortical damage on the basis of a similar experimental study. In all twelve animals, thickening of the dura overlying the tantalum was found in periods of from 16 days to four and a half months following implantation. The arachnoid showed similar but less marked reactions. Early encapsulation of this material, however, was not seen until three and a half months in two animals. This process was so marked in three additional dogs that adhesions bound the foil to the subjacent cortex.

Our experiences in man in this respect have corroborated the findings of Pudenz and Odom, rather than Delarue, Linell and McKenzie.

Ingraham and Bailey have recently introduced fibrin film as a dural substitute. Ten experimental animals were sacrificed from 24 hours to 6 months following its use. Only minimal tissue reactions were observed and the sub-
dural space was preserved throughout. The final result was the replacement of the film with a thin layer of fibrous tissue. It was further used clinically in 44 instances. Eighteen were removed for further study at periods varying from 14 hours to 81 days after implantation and the previous results were corroborated.

We have been able to observe the effects of tantalum foil when placed immediately over the cortex in six patients. The intervals between the first and second operations were 6, 21, 26, 31, 54 and 113 days. In each instance, the findings were invariably similar in all respects. A fine, thin, smooth, glistening, diaphanous membrane surrounded the foil. This envelope was very loosely adherent to the arachnoid and dura but was easily separated. No thickening of the arachnoid was seen. The cerebrospinal fluid pathways remained intact, and the subjacent cortex appeared smooth and glistening, with xanthochromia where previous contusion was present. The dura showed minimal thickening. However, in patients where the dura had been incised at previous operations, this reaction was particularly marked even when no substitute was employed. The foil showed no evidence of corrosion. Nor was there any evidence of adhesions of the encapsulated foil to the underlying cortex as mentioned by Delarue, Linell and McKenzie.¹

**CASE REPORTS**

**Case 1.**

**Skull Pathology.** Depressed fracture, squamous portion of left temporal bone.

**Mode of Injury.** Patient was struck over the left temporal region by a pitched baseball on 30 August 1942.

**Associated Injuries.** Patient was unconscious for several hours. Spinal fluid was grossly bloody but under normal pressure. There was transient motor dysphasia.

**Operation I.** Debridement with removal of depressed bone fragments, including spicules penetrating the dura and cortex, was performed on 24 October 1942. A segment of tantalum foil was placed over the cortical laceration and the dura repaired. A first-stage tantalum cranioplasty was then accomplished. [At present, the entire procedure is completed in one stage.]

**Course.** Convalescence was uneventful.

**Operation II.** A second-stage cranioplasty was completed 54 days later, on 17 December 1942. The tantalum foil was inspected and removed for study. It was found to be enveloped by a thin, diaphanous, translucent membrane. This was easily separated from the overlying dura and subjacent arachnoid, leaving the adjacent surfaces of these membranes smooth and glistening. The arachnoid had completely healed over the cortical laceration, and the site of the original injury to this membrane and the cortex could not be localized grossly. However, the cortex for some distance surrounding this area was yellowish and appeared to be that characteristic of traumatized brain but not necessarily related to the presence of tantalum foil. The dura was then sutured and tantalum plate inserted.

**Course.** The patient had an uneventful postoperative convalescence.

**Microscopic Examination.** The membrane removed consisted of a loose, wavy, fibrous tissue. There was no significant chronic inflammatory or foreign body reaction.

**Case 2.**

**Skull Pathology.** Compound, comminuted, depressed fracture, mastoid and squamous portions of the left temporal bone.
Mode of Injury. Patient's injuries were incurred in a truck accident on 26 March 1944.

Associated Injuries. Patient was unconscious for 48 hours. There were compound, comminuted fractures of the left humerus, radius and ulna, all at the junction of the middle and distal thirds of the bones. There were similar fractures at the bases of the fourth and fifth left metacarpal bones. There was a pronounced sensory dysphasia with agraphia and acoustic and visual verbal agnosia.

Operation I. Debridement and removal of bone fragments over an area 2 × 4 × 5 cm. was performed on 27 March 1944. The mastoid cells were involved. There was dural laceration and extensive laceration and contusion of the underlying cortex. A section of tantalum foil was left in the subdural position.

Course. There was marked improvement in the previous dysphasia. Electroencephalogram showed considerable delta activity over the left motor area and frequent spikes over the left occipital region. Much fast, irregular activity was seen over the entire left cerebral hemisphere. Encephalogram on 29 June 1944 showed moderate internal hydrocephalus, more evident on the left, and more particularly of the temporal horn. Patient had a series of generalized convulsions on the 4th and 5th of July.

Operation II. A tantalum cranioplasty was performed 113 days after the initial operation, on 18 July 1944. The dura was intact and only slightly thickened. The foil had crumpled and was covered with a thin film of tissue which was easily removed. The subjacent cortex was completely free from adhesions. The areas not covered by the tantalum were involved in a definite meningoencephalic cicatrix which was separated with little difficulty. The brain showed evidence of previous contusion and laceration. A piece of tantalum foil was again inserted subdurally and routine tantalum cranioplasty then accomplished.

Microscopic Examination. The envelope surrounding the foil was composed of connective tissue of varying density with no evidence of foreign body reaction.

Case 3.

Skull Pathology. Compound, comminuted, depressed fracture, squamous portion of left temporal bone.

Mode of Injury. Patient sustained a gunshot wound of the gutter type over the squamous portion of the left temporal bone on 5 July 1944.

Associated Injuries. Patient was unconscious for 30 minutes. There was a transient right hemiparesis, amnesic dysphasia and hyperpathia to the eighth dorsal dermatome on the right.

Operation I. On 6 July 1944, debridement and removal of bone fragments over an area 4 cm. in diameter was performed. There was laceration of both the dura and underlying cortex. A section of tantalum foil was then placed subdurally and the scalp was closed in the usual manner.

Course. This was uneventful, with subsidence of all previous symptoms. Electroencephalogram showed a slow wave focus and bursts of fast activity over the left temporal region. Encephalogram on 22 July 1944 showed very early dilatation of the left lateral ventricle.

Operation II. A routine tantalum cranioplasty was accomplished 21 days following the first operation, on 27 July 1944. The dura was not abnormally hypertrophied. There was a thin film of tissue covering the foil, both superficially and deep, and this was easily removed. There was no adherence to either the arachnoid or dura. Previous areas of cortical contusion were verified. A new segment of tantalum foil was inserted, dura closed, and tantalum plate inserted.

Course. Convalescence was uneventful.

Microscopic Examination. The tissue surrounding the foil was fairly well vascularized, loose connective tissue. No significant foreign body reaction or chronic inflammatory changes were noted.

Results obtained in the other three cases were similar to the above in all respects.
TYPES OF CASES

From 24 October 1942 to 27 September 1944 we have used tantalum foil subdurally in at least 45 recorded cases. These included: 16 cases following acute, compound, comminuted depressed skull fractures; 12 cranial defects, residual from previous debridement; 10 brain tumors; and 7 miscellaneous cases as follows: brain abscess, 2; degenerative lesions, 2; Ménière's disease, 1; arachnoiditis, 2 (one cerebellar and one lumbar).

We have also used the foil in an undetermined additional number of cases not recorded in the operative notes. It has been our routine to use tantalum beneath the dura in all cases in which a transcortical incision is employed, not only for cerebral trauma of any type but also in the removal of brain tumors.

Two patients have complained of "clicking sensations" over the involved area after the use of tantalum foil. In one the foil was applied after a suboccipital craniectomy, and in the other, after a debridement of a compound, depressed fracture over the midline involving both squamous portions of the frontal bone, before cranioplasty. Therefore, in cases in which tantalum foil is applied over the cortex, "clicking sensations" may be a frequent complaint in the presence of a cranial defect, but have not been described following cranioplasty or a routine osteoplastic flap.

CONCLUSION

Until fibrin film or some other more ideal substitute material becomes available, we feel that tantalum foil is well adapted for subdural application in the prevention of postoperative sequelae following intracranial surgery. Contrary to the experimental results of Delarue, Linell and McKenzie,¹ we have not found subdural tantalum foil associated with thickening of dura and arachnoid any more than is seen with ordinary operative procedures exposing the cortex. Many of the casualties returning from overseas theaters of operations have sustained penetrating intracranial wounds with resulting cranial defects and other evidence of neurological deficit. Cranioplasty has revealed a number with marked meningoencephalocerebral cicatrices, some having already developed epilepsy and other post-traumatic residuals, depending upon the site of injury. It is in this group, particularly during modern warfare, that the subdural use of tantalum foil would do much to obviate many of these serious sequelae.

REFERENCES