Plastic Coating of Intracranial Aneurysms with "EDH-Adhesive"

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The hazards of operation on intracranial aneurysms are well known; for some, there is as yet insufficient technical answer (e.g., rupture of the aneurysm during the exposure). The goal of operation has always been the prevention of repeated bleeding. In the past, the favored technic has been clipping or ligature of the stalk or pedicle bearing the aneurysm and, in most instances, this is still the most satisfactory technic. However, there are broad-based aneurysms whose necks cannot be clipped, and other cases in which attack on the neck means destruction of a potentially important branch of the vessel. These circumstances are particularly important with aneurysms of the middle cerebral artery, and it is for these sacs that the use of materials for wrapping the aneurysm has been particularly important. Hammered muscle, gauze, and other foreign materials have been used in the past, but there has been no certainty that the wall of the vessel actually would become stronger or less likely to rupture. Various plastic materials have been employed in recent years, including methyl methacrylate (Dutton²), synthetic resins (Selverstone¹,5), and silicone polymer (Todd et al.⁶). Handa⁸ has investigated a number of plastic materials, separately and in combination, and reported his results in a lecture at the University of Illinois en route to a formal presentation in Washington, D. C. in 1961.¹ Through him and by courtesy of Yoshitomi Pharmaceutical Industries, Ltd. of Osaka, Japan, we have been fortunate to receive samples of "EDH-adhesive," which he had found useful. Up to now, we have used this plastic material in 4 humans with intracranial aneurysms.

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Materials and Methods

"EDH-adhesive" is a mixture of 6 parts of methyl 2-cyanoacrylate monomer with a small amount of plasticizer (Eastman 910 adhesive), 3 parts of polysisocyanate (Desmodur T), and 6 parts of nitrile rubber (Hyvac No. 1041) in a nitromethane solution. It comes in dark glass ampules, as a thick viscous material, sometimes containing small solid white particles which do not interfere with the use of the material. The ampule is immersed in aqueous Zephran solution for 24 hours before use. The top of the ampule is broken off, and a camel's-hair brush is used to paint the viscous liquid onto the desired locus. The flow is somewhat aided by immersion of the ampule in warmed water during use. The aneurysm and its tributaries are covered completely, and then the solvent evaporates, leaving a thin film which adheres to the wall of the vessel. Evaporation is speeded up by blowing hot air on the aneurysmal site from a hair-drier held close to the wound. Surrounding tissues are protected by wet cottonoids (whereas the aneurysm and vessels to be coated must be dried before application of plastic). After 5 to 10 minutes the film is hard. The procedure is repeated several times to produce a hard impervious mass. When rupture of the sac is feared (because of adherence of the site of old rupture to the neighboring tissues) it is possible to isolate the neck or base, and paint it with adhesive, then to dissect a little further, paint, dissect, and so forth. Sometimes the thinned protrusions ("teats"), where 80 per cent of aneurysms rupture, can be isolated first, and painted with plastic to give additional protection while the rest of the sac is being dissected free. The film produced by EDH-adhesive is strong enough that a 0.4 mm film is said to resist a pressure of over 300 mm. Hg.

The same material has been used for holding together edges of the skin and also to close cerebrospinal-fluid fistulae. It may be used to coat the surface of the hypophysis and its stalk (after section of the stalk) to prevent regrowth of vessels instead of using a plastic sheet.

Case Reports

Case 1. On Sept. 1, 1961, a 49-year-old woman suddenly became unconscious, vomited, defe-
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cated and, when she awakened, had severe headache and stiff neck. A left lower facial weakness was not noticed until 9 days later, and this led to hospitalization. Lumbar puncture yielded yellow spinal fluid under normal pressure. Bilateral carotid and later right brachial angiograms showed bilateral aneurysms of the middle cerebral artery. On the left, the sac was at the site of origin of the first major ventral branch. On the right, the sac was at the bifurcation of the middle cerebral artery. It was bilobed, and was surrounded by a clear area, thought to be caused by hematoma. Branches of the middle cerebral artery appeared elevated in the lateral projection. The patient was transferred to the care of the senior author.

On Oct. 4, 1961, frontotemporal craniotomy was carried out on the right side, as the site of presumed bleeding. A somewhat encapsulated hematoma was found under the first temporal convolution, and when it was removed it was possible to locate the aneurysm in the anterior part of the sylvian fissure. The somewhat broad base was occluded with a Mayfield clip without impairing the blood supply to the surrounding brain.

On discharge, 11 days after operation, there was weakness of the right frontalis muscle and a central type of left lower facial palsy together with a left Babinski's sign. Because of the apparent convolution which initiated her illness, she was given Dilantin sodium by mouth.

Later there was a minor osteomyelitis of the bone flap which subsided with heat, chloramphenicol and tetracycline. Because of this infection, the planned left-sided operation was deferred until May 16, 1962. On May 11, 1962 an electroencephalogram revealed suppression of voltage and decreased sleep spindles in the left frontal area.

At operation, hypothermia was instituted and a small frontotemporal bone flap permitted access to the left sylvian fissure. Intravenous urea (1.5 gm./kg. body weight) was used to help gain room. The arachnoid was opened at the anterior end of the sylvian fissure, allowing visualization of the middle cerebral artery distally to the aneurysm, 1 cm. in diameter, bearing on its tip a 2 mm. narrow, red, thin-walled projection or teat. The surrounding brain was walled off with cottonoids until just the aneurysm and adjacent portions of the middle cerebral artery were exposed. EDH-adhesive was painted on with several coats, and at the end of the procedure the aneurysm was well covered with a firm, dense film, and the circulation was unimpeded.

The patient was up walking in 5 days. On the 8th day, left vertebral angiography revealed no abnormality. This was the only vessel not visualized hitherto. Left carotid injection of 60 per cent Renografin (for visualization of the plastic coated artery) led to an immediate focal seizure involving the right side of the body, so further angiography was not carried out. Convalescence was uneventful.

An electroencephalogram on Aug. 29, 1962, showed slow-wave activity in the left temporal and anterior temporal regions. When the patient was examined on May 27, 1963, she was doing full-time secretarial work, taking anticonvulsants (although she had had no further convulsions), and considered herself in good health.

Case 2. A 54-year-old salesman became suddenly unconscious on July 23, 1962. Spinal fluid was bloody at 300 mm. pressure. When he awakened, there was a central type of right facial palsy and complete motor aphasia. On July 28, 1962, the spinal fluid was still pink, and there were still some red blood cells in the spinal fluid on Aug. 4, 1962, although the pressure was now 190 mm. Bilateral percutaneous angiography revealed an aneurysm at the bifurcation of the internal carotid artery on the left, and another at the trifurcation of the left middle cerebral artery. In the lateral view, middle cerebral vessels were elevated, indicating a temporal hematoma and pointing to the middle cerebral aneurysm as the one that had bled.

On Aug. 10, 1962, under general hypothermic anesthesia, a left frontotemporal craniotomy was performed. Intravenous urea was given. The left frontotemporal cortex was blood-stained, and an intracerebral hematoma, 5 cm. thick, was found in the anterior end of the temporal lobe. The medial temporal tip was removed to allow access to the aneurysm, which arose by a broad base from the middle cerebral artery as it branched. Since the tip of the aneurysm was attached to surrounding gliotic brain tissue, it was left undisturbed while the middle cerebral artery and its branches, and the broad base of the aneurysm, were all painted with plastic. When this was solid, the tip of the aneurysm was cleared without rupture, and it too was coated. About 1 cm. of lateral fronto-orbital cortex was removed to allow access to the internal carotid artery at its bifurcation. The tip of the aneurysm pointed to the operator. There was no sign of nearby bleeding. The tip was cleaned and coated with plastic. The medial inferior part of the aneurysm and adjacent carotid artery were also coated but the lateral part of the neck was not coated, for to have cleared it would have meant a larger sacrifice of normal left frontal lobe. It was considered safer to leave this alone since most aneurysms rupture at the tip.

Postoperatively, the patient did well for 3 days then became increasingly leathargic. When this had progressed almost to coma, left carotid angi-
ography was repeated on Aug. 17, 1962. This disclosed no change in the aneurysms but there was marked displacement of the middle cerebral vessels and the posterior communicating-posterior cerebral stem, indicating probable recurrent intracerebral hematoma on the left.

On the same day, the craniotomy was reopened and a large intratemporal hematoma continuous with a sylvian hematoma and a subdural hematoma was evacuated. No obvious source of bleeding was found. The plastic-coated aneurysms were inspected and no sign of bleeding was found. The coatings were quite solid and hard.

Postoperatively, the patient's course was one of very slow improvement, complicated by tracheostomy, renal infection, etc. By the time he was transferred to a Veterans Administration Hospital on Oct. 17, 1962, he was up, walking, had good comprehension of speech, but could say only 4 or 5 words, contrasted to the single word "two" preoperatively. He was last examined on May 2, 1963, with much improvement in his aphasia.

Case 3. A hitherto healthy widow of 60 had pain in the head on Oct. 18, 1962, and a major seizure on the following day. On Oct. 20, 1962, the spinal fluid was bloody grossly. Percutaneous carotid angiography showed a lobulated aneurysm of the right middle cerebral artery.

On Oct. 31, 1962, under general anesthesia with hypothermia to 31°C., a right frontotemporal craniotomy was done. Intravenous urea (1.5 gm./kg. body weight) was given. By aspirating the anterior portion of the right first temporal convolution, it was possible to approach the lobulated aneurysm which arose from the middle cerebral artery. Two major branches arose from the aneurysm, so there was no neck to be clipped. The aneurysm and the adjacent vessels were cleaned, dried, and coated—first on the lateral aspect and then on the medial side. These were reached by aspiration of a small amount of adjacent frontal operculum. Two small teat-like projections were found laterally. Although the temporal cortex was blood-stained, there was no intracerebral hematoma, nor had one been suspected from the preoperative angiogram.

No postoperative angiogram was obtained. The patient recovered well from the operation and was discharged ambulatory on Nov. 10, 1962, with no obvious neurologic deficit. When last seen on Jan. 16, 1963, she was free of neurologic complaints and findings on examination were within normal limits.

Case 4. Severe headache, nausea and vomiting preceded by a half hour the sudden loss of consciousness of an 18-year-old high-school student on Feb. 11, 1963. Bloody spinal fluid was found at 440 mm. pressure of fluid. Because of a transitory left hemiparesis, a right carotid angiogram was done on Mar. 8, 1963. This disclosed a large aneurysm at the bifurcation of the internal carotid artery, and the patient was transferred for treatment to the University of Illinois Hospitals on Mar. 11, 1963. Two days later left carotid angiography was done, disclosing no abnormalities.

On Mar. 21, 1963, craniotomy was performed using hypothermia and intravenous urea. Portions of the lateral orbital region of the right frontal lobe and of the medial portion of the temporal pole were resected to permit visualization of the internal carotid artery and its bifurcation. The aneurysm was found to arise by a broad base from the bifurcation, and a fairly large perforating artery also arose at the same place, making application of a clip unwise. The aneurysm pointed medially and upward and it was felt that to completely encircle it would invite rupture and excessive removal of brain tissue. Accordingly, EDH-adhesive was painted over the base and accessible portions of the remainder of the aneurysm, including the thinned tip. The carotid artery was seen to be in spasm following the manipulations necessary to get as much plastic as possible at the base and thinned tip. Pieces of Gelfoam were placed around the operative site, and the wound was closed.

Postoperatively there again were a left hemiparesis and right oculomotor palsy, but these had subsided by the time the patient was discharged to his parents' care on Apr. 6, 1963.

Discussion

The postoperative hematoma of Case 2 permitted repetition of angiography which disclosed no change in the aneurysms, and led to examination of the plastic coating, which was firm and apparently impervious. The hematoma is ascribed to leakage from small vessels associated with brain shrinkage secondary to urea and removal of the first hematoma.

Obviously it is best to coat the entire aneurysm and the entering and exiting vessels, but when this cannot be done without risk of hemorrhage or damage to important structures it has seemed the better part of valor to coat those parts most liable to rupture. These thin-walled reddish teats or projections usually contrast well with the rest of the greyish firm aneurysmal sac. Often the swirl of blood can be readily seen under the
tissue-paper thin wall. To protect these areas alone might well be sufficient treatment but, when possible, the entire sac and feeders should be included.

By walling off surrounding intact tissues, it is usually possible to keep the plastic where it is wanted. Exactly how much irritation and possible epileptogenic effect this plastic may have is not clear. Current animal experimentation and long-term human follow-up may help elucidate this matter. Two of the 3 patients of this series had had seizures prior to operation and are on anticonvulsants because of them.

The plastic material used in these patients has a number of advantages over those in current use. (1) It is furnished sterile in small containers, and large amounts need not be wasted. (2) It can be applied with simple means (artist’s hair brush) and is simply dried with a commercially available handheld hair-drier. Some protective sterile sleeve or apron around the drier should be provided to help eliminate the possibility of contamination. It has not seemed worth while to try to filter or sterilize the air blown on the aneurysm. (3) Very little heat is produced in the drying process in comparison to some cranioplastic materials adapted for coating of aneurysms. (4) The time for drying is not excessive, and the film produced seems to be of adequate strength.

So far, we have used EDH-adhesive only for aneurysms of the middle cerebral artery and those at the bifurcation of the internal carotid artery. Only further use will determine if it can be used on aneurysms elsewhere.

Summary

Three patients with aneurysms of the middle cerebral artery have had the aneurysms coated with a fast (5–10 minutes) drying mixture of plastic materials in nitromethane solution (“EDH-adhesive”). In 1 of these patients, an additional unruptured aneurysm of the bifurcation of the internal carotid artery was also coated. A fourth patient has had the plastic applied to an aneurysm of the bifurcation which had bled once. The longest follow-up to date is 12 months, and no obvious complications caused by the material have been encountered. The ease of application, firmness of plastic film, good adherence to the wall of the vessel seem to indicate a great potential use for this material.

References