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Intravascular Polymer Material Following Coil Embolization of a Giant Cerebral Aneurysm

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Abstract

We report the case of an 87-year-old female who died following coil embolization of an intracerebral giant aneurysm. Guglielmi Detachable and Matrix2 Coils were utilized during the procedure to occlude the surgically untreatable left supraclinoid carotid artery aneurysm. Postprocedure imaging studies showed scattered areas of acute infarct involving multiple bilateral vascular territories.

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Autopsy confirmed widespread infarction due to embolized foreign material, morphologically consistent with hydrophilic polymer originating from the coated Matrix coil and Terumo Glidewire. Polymer gel is now widely used on several medical devices for interventional procedures worldwide, and we suspect that risks associated with iatrogenic embolization of this substance are under-recognized.

Keywords

hydrophilic polymer; embolization coil; guidewire; cerebral saccular aneurysm; granulomatous inflammation; cerebral infarct

Introduction

Hydrophilic polymer materials of various composition have long been applied as coating to endovascular devices in order to ease navigation within tortuous vessels, decrease endothelial trauma, and reduce intraprocedural thrombotic phenomena. Their use has allowed for advancements in transradial approach during cardiac catheterization. Polymer-coated aneurysm coils, such as Hydrocoils (Terumo Medical, Microvention, Aliso Viejo, CA), have been shown to facilitate volumetric occlusion of aneurysms by inducing inflammation and thrombus organization, which according to some studies, allows for use of less total coil material, decreasing associated risks [1].

A prospective randomized trial has shown that endovascular embolization of ruptured aneurysms is associated with reduced morbidity/mortality compared with surgical clipping [2]. However, iatrogenic embolization of polymer gel is associated with endovascular surgeries, and the frequency of resulting tissue infarction may be under-recognized. We describe the first case of coil embolization in which widespread deposition of polymer gel occurred within intracerebral blood vessels, contributing to death of the patient.

Case Summary

The decedent was an 87-year-old female (nonsmoker) with a history of hypertension, peripheral vascular disease, chronic renal insufficiency, coronary artery disease, and congestive heart failure, and a 20-year known history of a surgically untreatable intracranial aneurysm. She presented to an outside hospital 14 days prior to death, reporting acute onset of severe headache and neck stiffness. Imaging studies showed Fisher grade 4 subarachnoid hemorrhage, with a ruptured left supraclinoid carotid artery giant aneurysm (Hunt-Hess grade 2) (Fig. 1A-B). The patient (who was unresponsive following the CT study) was intubated, treated with dexamethasone, mannitol, and phenytoin, and was transferred to our institution.

She was treated with routine subarachnoid hemorrhage management strategies, and being a poor surgical candidate, underwent embolization of the aneurysm 12 days prior to her death. During the procedure, a 6 French 80 cm shuttle sheath (Cook Inc., Bloomington, IN) was inserted into the right common femoral artery over a 0.035 Cook Bentson guidewire (Cook Inc., Bloomington, IN). A Simmons 2 catheter (Terumo Medical, Somerset, NJ) was inserted and advanced into the aorta. However, due to an excessively tortuous aortic arch, it was not possible to select the left common carotid artery. A 5F VTK catheter (Cook Inc., Bloomington, IN) and 0.038 Terumo Glidewire (Terumo Medical, Somerset, NJ) were instead used to advance the shuttle sheath into the left common carotid artery. An Echelon 10 microcatheter (ev3 Neurovascular, Irvine, California) and fasDasher 14 microguidewire (Boston Scientific Neurovascular, Fremont, California) were used to catheterize the aneurysm. A total of 7 Guglielmi Detachable coils (Boston Scientific Neurovascular, Fremont, CA) and 12 Matrix2

coils (Boston Scientific Neurovascular, Fremont, CA) were used to fill the aneurysm. Following the procedure, the aneurysm showed no residual contrast filling.

Post-procedure, the patient was slow to regain consciousness but was symmetric in spontaneous movements. The day following the procedure, she developed right hemiparesis. She never fully regained consciousness and was clinically diagnosed with a left middle cerebral artery (MCA) territory infarct. MRI (postoperative day 2) revealed areas of hyperintense signal on T2-weighted and FLAIR sequences with associated diffusion restriction within the left frontal, temporal, parietal, and occipital lobes, with involvement of the left insular cortex, caudate nucleus and putamen, representing acute infarcts in the left MCA and posterior cerebral artery (PCA) territories (Fig. 1C). Multiple small, scattered areas of acute infarct were visualized in the cerebellum (bilateral hemispheres, Fig. 1D), pons, right parieto-occipital lobes, right centrum semiovale, and right caudate head. Given the presence of multiple infarcts involving several bilateral vascular territories, findings were suggestive of embolic stroke. Concurrent MR angiogram showed stable occlusion of the aneurysm with diminished flow signal intensity in Sylvian branches of the left MCA, signifying possible emboli in the distal MCA territory.

A right frontal ventriculostomy catheter was placed 11 days before death, and medical workup ensued to determine the origin of the emboli. Bilateral upper extremity, carotid, axillary, subclavian, brachial, and radial arteries were unremarkable by Doppler ultrasound studies. Echocardiography with contrast (bubble study) showed thickening of the aortic and mitral valves with a right-to-left shunt, indicating patent foramen ovale. Based on these findings, a cardiac source for the patient's emboli could not be clinically excluded.

Over the next week, the patient developed cyanosis of the digits, necrosis of the tongue, polymicrobial pneumonia, urinary tract infection, and progressively worsening renal function. Despite percutaneous tracheostomy with ventilatory support and institution of intravenous inotropic agents, the patient developed cardiorespiratory collapse and died.

Autopsy Findings

General autopsy revealed cyanosis of the fingertips and necrosis of the tongue. There was ulcerative atherosclerosis of the aorta with an infrarenal abdominal aortic aneurysm (6 cm), organizing pneumonia, bilateral renal cortical retention cysts, and cardiac hypertrophy with patent foramen ovale (heart weight 455 grams; left ventricular wall thickness 2.0 cm).

Examination of the brain showed a left supraclinoid (bilobed) 2.9-cm aneurysm with diffuse softening of the left parieto-occipital lobes (fresh brain weight was 1320 grams). Subarachnoid blood with an acute/subacute hematoma were present in the left Sylvian fissure, with a smaller hematoma adherent to the left mesial temporal lobe. Minimal patchy non-occlusive atherosclerosis (~10% stenosis) was noted within the basilar artery and left MCA. Focal thrombus was identified only in distal branches of the left MCA.

Bivalving the aneurysm revealed luminal occlusion by thrombus and filaments of metal wire, consistent with recent embolization procedure (Fig. 2A). Coronal sections of the cerebral hemispheres revealed encephalomalacia of the left MCA/PCA territories.

Histologic sections confirmed large left MCA/PCA zones of necrosis. Additionally, microfoci of infarct were seen within the cortical/subcortical cerebral hemispheres, brainstem, and cerebellum (approximately 20 lesions bilaterally in patternless distribution). Scattered giant cells and granulomas (including intravascular granulomas) were present in these areas (Fig. 2B-E), although no acute inflammation or micro-organisms were observed. Occasional needle-like structures were identified within granulomas in the left parietal lobe (Fig. 2D-E). Granular,

nonrefractile, nonpolarizable foreign material was found obstructing lumina of several small intraparenchymal vessels within the left cerebral cortex (parietal and frontal), right cerebral cortex (parietal), cerebellum, and brainstem (Fig. 2F-M). The intraluminal material was predominantly blue-gray, and rarely pink-red in color. Clearly-defined radial zones of subcortical infarct were noted adjacent to several of the obstructed small vessels.

Microscopic Examination of Medical Devices

An unused Matrix2 coil was flushed with phosphate buffer saline. One segment of coil was stretched by pulling opposite ends apart with forceps. The segment was then stained with hematoxylin and eosin (H&E), mounted on a glass slide and coverslipped. A steel blade was used to scrape off coating from other segments of coil, yielding strips of gel which were submitted for routine tissue processing (i.e., the material was formalin fixed, paraffin embedded, sectioned, mounted on a glass slide, stained with H&E, and coverslipped). The procedure was repeated on hydrated segments of a Terumo Glidewire and Echelon 10 Microcatheter. Histologic examination revealed the morphology of the devices (Fig. 3).

Discussion

The Matrix2 detachable coil (Boston Scientific Neurovascular, Fremont, CA) was approved by the United States Food and Drug Administration in 2002 and consists of a platinum core lined by polysorb (biodegradable polymer composed of 90% polyglycolic acid and 10% polylactic acid). The coated coils, as well as concurrently used polymer-coated supplies (such as microcatheters and guidewires), account for a surface area totaling several meters in length. The abundant amount of gel utilized during a single procedure may introduce unique complications, whereby polymer stripped off the devices may deposit and/or embolize within vessels, causing unintentional occlusion of small vessels, leading to infarct.

Barnwell et al (1997) [3] showed foreign bodies in small arteries of three patients after use of an infusion microcatheter for angiography (the Fastracker-18 was subsequently discontinued by the manufacturer). Since then, granulomas have been noted at the access site following cardiac catheterization [4-8]. "Aseptic" and "chemical meningitis" have also been reported in five patients [9,10]. Fealey et al (2008) [8] describe a case of coil embolization that resulted in numerous intracerebral granulomas and "sterile microabscesses", some of which harbored needle-like material resembling polymer filament core originating from a coated embolization coil (in their case, Cerecyte [Micrus Endovascular, San Jose, CA], delivered via Excelsior microcatheter [Boston Scientific, Natick, MA]). However, Fealey et al did not show definite intravascular foreign material. We describe an additional case of this phenomenon wherein 40-50 cerebral vessels were stenosed or occluded by giant cells, foreign material and/or granulomata. Moreover, in the current case, embolized foreign material contributed to the patient's death.

Summary

We describe the first case of coil embolization for intracerebral aneurysm in which polymer material deposited in unpredictable arterial sites, inducing granulomatous reaction and scattered infarcts in the brain, brainstem, and cerebellum. We have observed similar findings in several other patients who underwent interventional procedures at UCLA Medical Center during the past two years; this is the subject of ongoing investigations.

The frequency of the discussed phenomenon of polymer embolization is unknown. However, it may account for a significant proportion of failed endovascular procedures. Polymer gel is now widely used on several medical devices for interventional procedures worldwide, and we

suspect that embolization of material from such devices occurs more frequently than the sparse literature on this topic suggests.

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Figure 1.

Pre-procedure Imaging: A) Post contrast CTA of the brain source image shows laterally projecting enhanced saccular aneurysm in the left supraclinoid ICA (arrow), and B) conventional cerebral angiogram (lateral projection of selective left internal carotid artery angiogram) shows the bilobed aneurysm, projecting posteriorly from the communicating segment of the left supraclinoid carotid artery (the left posterior communicating artery is patent). **Post-procedure Imaging:** Diffusion-weighted images from noncontrast MRI of the brain (post-procedure day 2) demonstrate foci of acute infarcts, with associated diffusion restriction, involving C) a large portion of the left middle cerebral artery territory and right caudate nucleus, and D) the bilateral cerebellar hemispheres (arrows).

Figure 2. Findings at autopsy

Gross Findings: A) Bivalved giant aneurysm at the left ICA-posterior communicating arterial junction shows iatrogenic intraluminal thrombus and metal coils. **Microscopic Findings:** B) Granuloma within the lumen of a small intraparenchymal blood vessel, and C-E) scattered giant cells and granulomata within the subcortical white matter. Many granulomata contained blue-gray, nonpolarizable foreign material, some with “needle-like” appearance (D-E). F-M) Frequent intraluminal foreign material and granulomatous reaction was seen in small arteries of the F) right parietal lobe, G) left pons, H) leptomeningeal vessel of the posterior fossa, I) cerebellum, J) midbrain, K) left frontal lobe, L) left parietal lobe, and M) mid-pons (B-M, H&E, 600X at original magnification).

Figure 3.

Microscopic appearance of hydrophilic polymer was histologically indistinguishable from foreign material seen in small intracerebral blood vessels. A-B) Matrix2 Coil: A) Section of an uncoiled segment shows hydrophilic coating (arrows) as weaved filaments of gel wrapped around the metal coil (arrowheads). The filament core is lost during processing (H&E, 400X), and B) Smear preparation shows polymer as granular, basophilic, nonrefractile, nonpolarizable substance (H&E, 1000X). C-D) Terumo Glidewire: Partially uncoiled tip shows granular eosinophilic polymer coat (solid arrows) surrounding the metal coil (arrowheads) and filament core (open arrow). E) H&E, 400X, and F) H&E, 600X.