Hydrophilic polymer embolization after thoracic endovascular aortic repair

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ABSTRACT

Hydrophilic polymer embolization is a rare complication after endovascular procedures that is currently underappreciated. Present understanding on this phenomenon relies on sparse case reports with histologic evidence of foreign polymers in end-organ tissue. Here, we report two deaths associated with hydrophilic polymer embolization after complex thoracic endovascular aortic repair. (J Vasc Surg Cases and Innovative Techniques 2019;5:423-6.)

Keywords: HPE; TEVAR; Foreign body; End-organ ischemia

Rapid advancements of endovascular devices in the last decade have paved the way for novel interventions for vascular diseases. The development of hydrophilic coatings has further improved the handling of endovascular devices, thereby allowing smoother and more precise targeting of treatment areas. However, in the past few years, there have been increasing case reports of hydrophilic polymer embolization (HPE) that have resulted in a range of clinical sequelae from asymptomatic to death. Here we report our experience with two fatal cases of HPE after thoracic endovascular aortic repair (TEVAR). Both patients' families consented to the publication of these cases.

CASE REPORTS

Case 1. A 74-year-old woman presented with extent II thoracoabdominal aortic aneurysm with a maximum diameter of 6.5 cm. Given concomitant iliac stenotic disease, open thoracoabdominal repair was attempted. During periaortic dissection, neurophysiologic monitoring noted complete loss of somatosensory and motor evoked potentials bilaterally in addition to hemodynamic instability. Given the high risk of spinal cord ischemic injury, the operation was aborted. Six months later, she returned for a hybrid procedure of abdominal visceral debranching and TEVAR. Her comorbidities included coronary artery disease, chronic obstructive pulmonary disease, hypertension, hypothyroidism, degenerative disk disease, and diverticulosis.

Surgery was done with a midline laparotomy and bilateral groin cutdowns. Following an infrarenal aortobifemoral bypass with a polyethylene terephthalate (PETE) graft, four-vessel debranching was completed. This was done using Gore hybrid grafts (W. L. Gore & Associates, Flagstaff, Ariz). On the back table, a 6-mm hybrid graft was sewn onto an 8-mm hybrid graft. The 8-mm proximal graft was then sewn onto the right external iliac artery. The 6- and 8-mm grafts were then deployed into the left renal artery and the superior mesenteric artery (SMA), respectively. Similarly, another Y-configuration hybrid graft was made with 7- and 8-mm hybrid grafts deployed into the right renal and celiac arteries, respectively, with the inflow from the left external iliac artery. Last, an 11-mm PETE graft was sewn onto the aortobifemoral bypass as an endovascular conduit.

A 32- × 160-mm tapered Cook Alpha thoracic graft (Cook Medical, Bloomington, Ind) was first deployed. A tapered 40- × 208-mm tapered graft was then inserted and landed distal to the subclavian artery. Last, a third tapered 36- × 157-mm graft was inserted as a bridge. A compliant balloon was used in the graft overlap regions and the distal seal zone. No sign of endoleak was noted, and successful perfusion to the four visceral vessels was observed. At the end of the procedure, the right leg demonstrated some signs of worsening ischemia, and therefore simple balloon angioplasty was done.

Postoperatively, she developed an acute kidney injury as well as aspiration pneumonia. She was extubated on postoperative day (POD) 7 but suffered a bradycardiac arrest on POD 8, requiring reintubation. After arrest, she was found to have a subacute stroke, probably secondary to an embolic shower to the left frontal and occipital cortex (Fig 1), leaving her with partial right hemiparesis. On POD 14, she went into shock and fulminant hepatic failure. Computed tomography (CT) demonstrated a grossly ischemic liver and an ischemic left kidney (Fig 1). She became densely paraplegic on POD 15. The patient was transitioned to comfort care and died on POD 17.

Autopsy determined the cause of death to be systemic shock and multiorgan failure. Microscopic hydrophilic polymer emboli within multiple organs likely contributed to tissue infarction.

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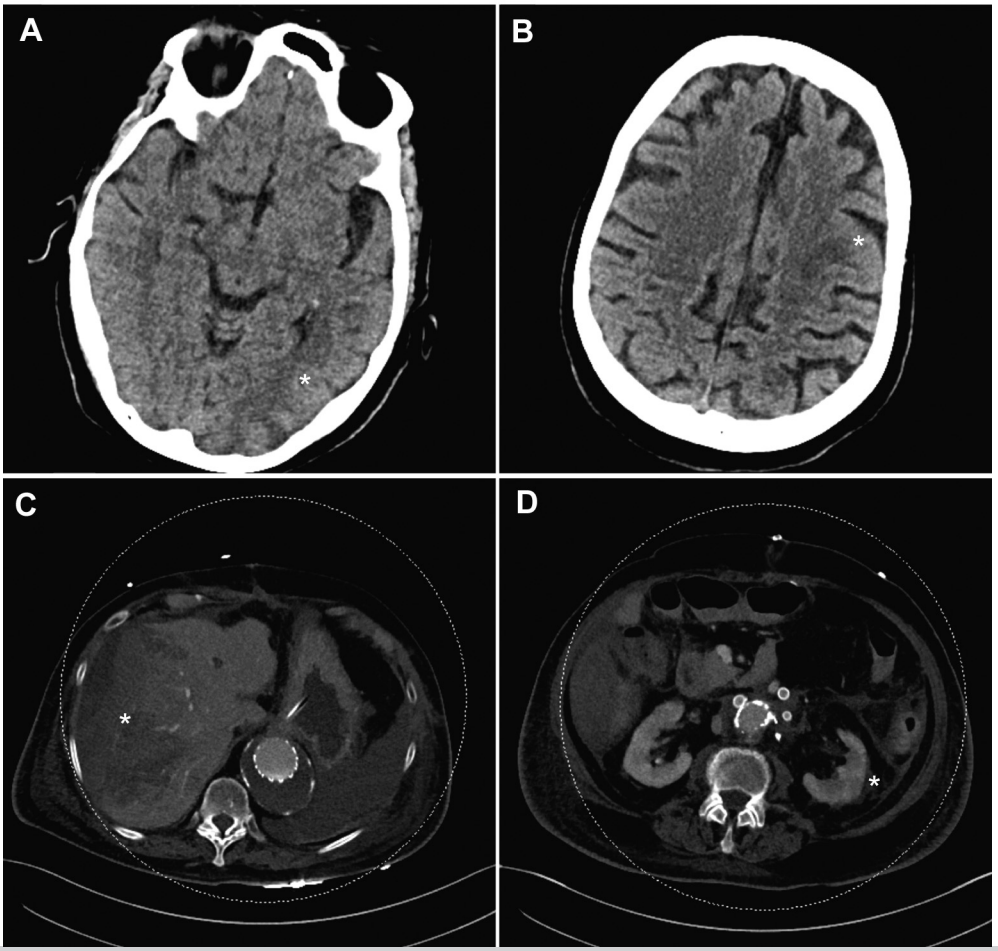

Fig 1. Computed tomography (CT) scan demonstrating left occipital **(A)** and middle cerebral artery **(B)** infarction. Visceral infarction is demonstrated in the heterogeneous right liver **(C)** and left kidney **(D)**. *Site of tissue infarction based on imaging.

Scattered nonorganic microemboli in the liver, kidneys, brain, lungs, spleen, bowel, and lower extremity soft tissue were found (Fig 2). However, all visceral bypass grafts were patent. The pathology report described the appearance of the hydrophilic polymer embolic material as similar to that in previous reports.[1] It is unclear whether the polymer emboli contributed to the intraoperative finding of worsening right leg ischemia.

Case 2. A 75-year-old woman initially presented, at the age of 69 years, with a type B dissection with intramural thrombus compromising bilateral renal artery flow. Only the right kidney was successfully salvaged with an iliorenal bypass. Two months after discharge, an extent II thoracoabdominal aortic aneurysm was noted on follow-up CT, measuring 4.2 cm. During 6 years, the aneurysm degenerated to 6 cm in diameter, thereby necessitating definitive treatment. Her other comorbidities included a history of chronic mesenteric ischemia secondary to atherosclerosis requiring celiac and SMA angioplasty and stenting, hypertension, dyslipidemia, chronic smoking, anal squamous cell carcinoma, bilateral cataract surgeries, history of breast cancer, osteoarthritis, and a remote appendectomy.

She had a two-stage procedure. She first underwent a left carotid-subclavian transposition, which she tolerated well. Three months later, she returned to the hospital to have her aneurysm treated. Following a midline laparotomy and isolation of the abdominal aorta, a right ilioceliac bypass was done with a 6-mm PETE graft, and the celiac trunk ostium was ligated. Given the small iliac arteries, a 10-mm PETE graft was sewn end to side to the right common iliac artery as a conduit.

The first stent graft, a Cook Zenith Alpha (ZTA-PT 32-155), was deployed in zone 2, covering the origin of the left subclavian artery. Two custom stent grafts were then deployed with perfusion branches in the thoracic aorta and an SMA branch graft in the abdominal aorta. An iliac branch extension was inserted into the right common iliac artery (ZSLE 13-56). The completion angiogram demonstrated a good seal. Retrograde cannulation of the SMA was done to gain access into the TEVAR branch. This was bridged with two Atrium Advanta V12 stents (Maquet Getinge Group, Rastatt, Germany). After this, the SMA arteriotomy was closed primarily. Last, the right iliac conduit was sewn onto the left common iliac artery, essentially forming an iliac-iliac crossover graft because the proximal left common iliac artery was covered by the endograft.

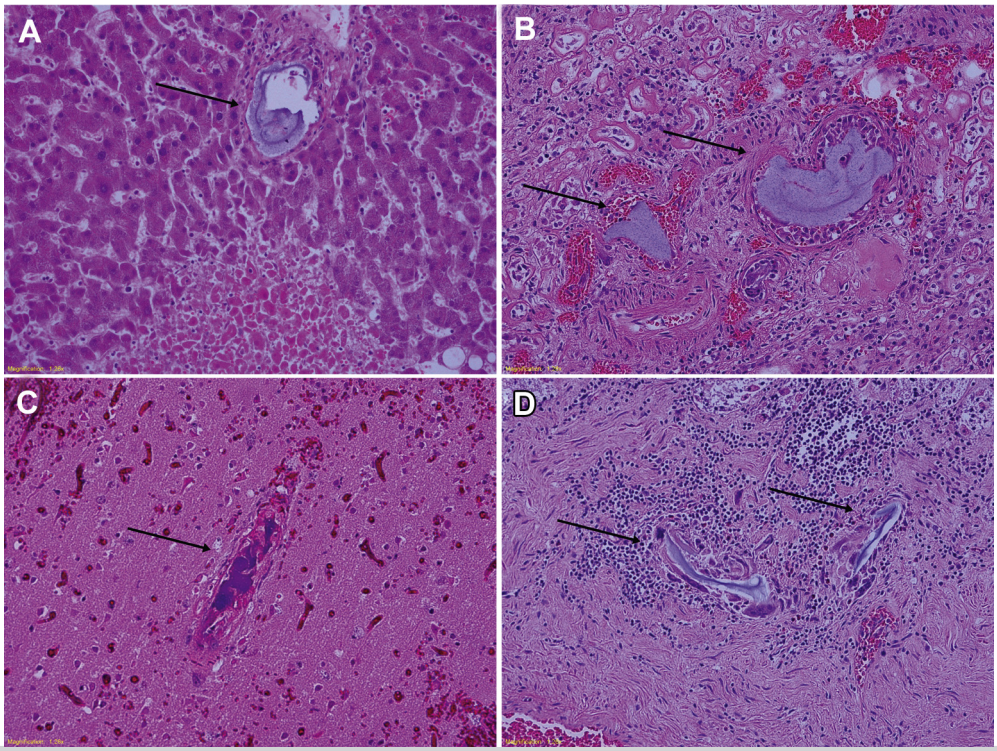

Fig 2. Case 1. Hydrophilic polymer embolization (HPE; *arrows*) in histologic slices of the liver **(A)**, kidney **(B)**, brain **(C)**, and small bowel **(D)**. Surrounding inflammatory cells were also demonstrated. Tissues were stained with hematoxylin and eosin (magnification ×400 for **A-C** and ×200 for **D**).

The patient immediately developed seizure postoperatively and deteriorated on POD 2 when her neurologic responses did not recover. A non-contrast-enhanced CT head scan and magnetic resonance imaging revealed restricted diffusion in the left frontal cortex, in keeping with an acute infarction, as well as several microbleeds but no occlusion of the middle cerebral artery (Fig 3). Her condition continued to worsen and was made comfort care on POD 5.

Autopsy examination confirmed hydrophilic polymer microemboli scattered throughout the brain. Fragments of polymer coating were identified in the right kidney with associated infarction and glomerulosclerosis of nearly half the parenchyma (Fig 3). Given her already compromised renal function, this was thought to have contributed to her failing health; however, compared with her neurologic symptoms and findings, her renal failure was unlikely to be the cause of death. Last, emboli were also discovered embedded in the aortic adventitia and liver (Fig 3).

DISCUSSION

Hydrophilic coatings provide a smooth interphase during procedures. However, it is well known that the polymer coating can be dislodged by mechanical forces during typical use. Despite this, the rate of reported serious adverse events is exceedingly low. A review by Mehta and Mehta[2] revealed nine deaths from HPE since 2010 with 11 device recalls. In almost all cases, the emboli are found on postmortem autopsy, suggesting that the rate of subclinical and nonfatal embolization is likely to be much higher. Chopra et al[1] reviewed retrospective studies from autopsies,[3] coronary stenting procedures,[4] and endovascular aortic repairs,[5] revealing incidence rates ranging from 4% to 45%.

It is unclear whether the amount or size of HPE is associated with the clinical outcome. Conceivably, a larger hydrophilic device kept inside the patient for a longer time is likely to generate a greater amount of HPE. This was demonstrated by Stanley et al[6] in swine models. Consequently, complex TEVAR cases requiring large hydrophilic sheaths inside the patient for long periods may result in significant amounts of polymer dislodgment and are more likely to have detrimental clinical sequelae as seen in the two cases presented here.

Overall, HPE is an underappreciated complication after endovascular interventions. Whereas the reported clinical sequelae appear to be rare and often are found only on autopsy, partial or total organ injury could have previously been attributed to other causes. Physicians should become more aware of this phenomenon and include it in their differentials of unexplained organ failure after complex endovascular procedures. Better understanding of its incidence will rely on diligent reporting by physicians of this rare complication. Future studies should also focus on the differences in the rate

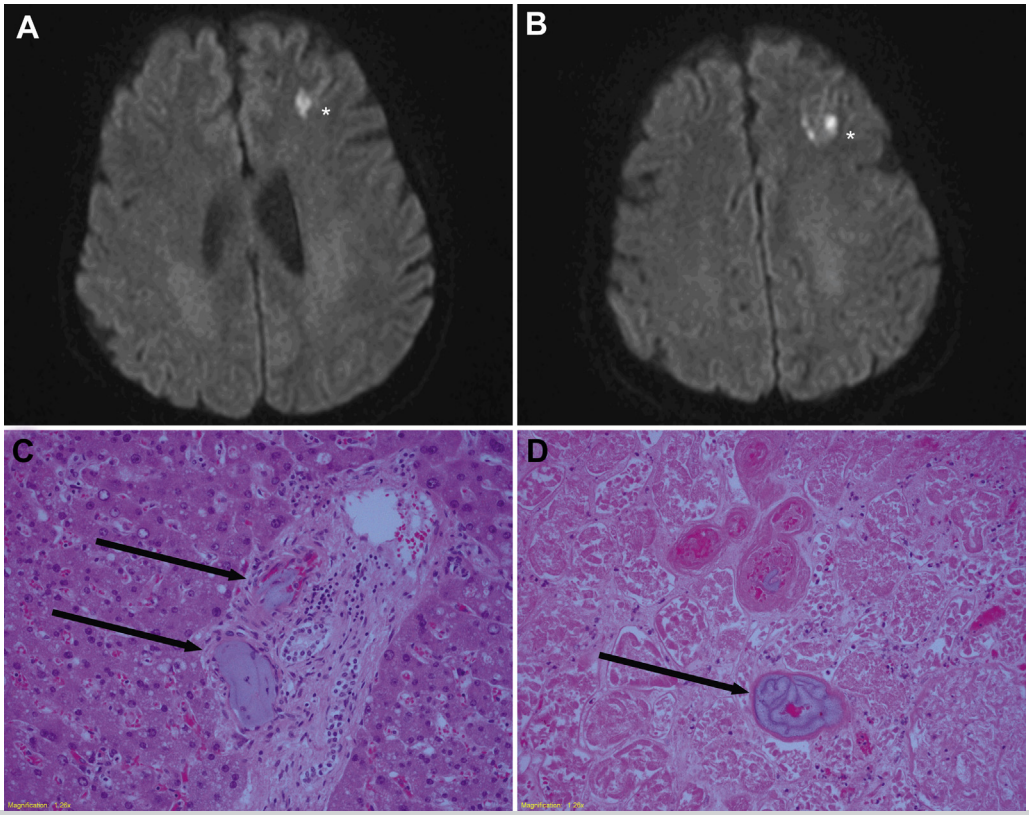

Fig 3. Case 2. **A** and **B,** Magnetic resonance images demonstrating left frontal lobe subcortical acute infarct and several punctate cortical microbleeds (*). **C** and **D,** Histology demonstrating hydrophilic polymer (*arrows*) embedded in liver **(C)** and right kidney **(D)** as well as surrounding inflammatory responses. Tissues were stained with hematoxylin and eosin (magnification ×200).

of HPE from different types of sheaths and their association with tissue injury to aid manufacturers in future developments.

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