Treatment of Type I Endoleaks after Endovascular Aneurysm Repair of Infrarenal Abdominal Aortic Aneurysm: Usefulness of *N*-butyl Cyanoacrylate Embolization in Cases of Failed Secondary Endovascular Intervention

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ABSTRACT

Purpose: To evaluate the technical feasibility and effectiveness of *N*-butyl cyanoacrylate (NBCA) embolization using a percutaneous transabdominal or a transarterial approach in the failed secondary endovascular treatment of type I endoleaks after endovascular aneurysm repair (EVAR) of infrarenal abdominal aortic aneurysms.

Materials and Methods: From 2000–2007, seven patients with failed secondary endovascular treatment of type I endoleaks (five patients with type Ia endoleak, one patient with type Ib endoleak, and one patient with type Ia and Ib endoleaks) were treated with embolization using NBCA with or without a coil. Embolizations were performed using either a percutaneous transabdominal ($n = 5$) or a transarterial ($n = 5$) approach. Four patients underwent a single session of embolization, and three underwent two sessions of embolization. The duration between EVAR and endoleak treatment was 9.6 months ± 15.3 (mean ± standard deviation; range 0–42 months). Follow-up computed tomography (CT) scans were evaluated for changes in size and shape of the aneurysm sac and presence or resolution of endoleaks. The follow-up period after endoleak treatment was 18.0 months ± 20.4 (mean ± standard deviation; range 0–53 months).

Results: Technical success was achieved in six patients with complete resolution of the endoleak confirmed by follow-up CT scans. One technical failure was observed in a patient who eventually underwent surgical conversion. There were no procedure-related complications.

Conclusions: Embolization with NBCA by a percutaneous transabdominal or a transarterial approach for the treatment of type I endoleaks after EVAR was technically feasible and clinically effective, with no major complications.

ABBREVIATIONS

EVAR = endovascular aneurysm repair, IMA = inferior mesenteric artery, NBCA = N-butyl cyanoacrylate, PTA = percutaneous transluminal angioplasty

Since endovascular aneurysm repair (EVAR) was first reported in 1991 by Parodi et al (1) for infrarenal abdominal aortic aneurysms, endovascular stent grafting has been a therapeutic option for conventional open repair of infrarenal abdominal aortic aneurysms. Compared with open repair, EVAR is less invasive and has a lower risk of perioperative morbidity (2,3).

Several major complications are associated with EVAR, including stent-graft migration, graft limb thrombosis, peripheral embolization, graft infection, and endoleaks. Endoleaks are the most common major complication after EVAR. Endoleaks are usually divided into five types (4). Type l endoleaks are indicative of a persistent perigraft channel of blood flow, caused by an inadequate or ineffective seal at the proximal or distal graft ends or attachment zones (5). The risk of rupture is high in such patients; secondary intervention is mandatory in most cases

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(4,6). Although transcatheter embolization of type I endoleaks via the transarterial route was described by Golzarian et al (7) in 1997, the current favored methods of endovascular treatment involve securing the attachment site with balloon percutaneous transluminal angioplasty (PTA), stent-graft extension, or using a stent at the proximal attachment site. These techniques have some limitations, however. Balloon PTA and stent placement are not always sufficient for the exclusion of type I endoleaks, and stent-graft extension can be placed only in cases with sufficient additional anchoring area (8). If these methods fail to exclude type I endoleaks, surgical conversion or new endovascular techniques, such as embolization, should be considered (8,9).

A liquid embolic agent such as *N*-butyl cyanoacrylate (NBCA) (Histoacryl, B. Braun, Tuttlingen, Germany) has been used as a possible treatment for type II endoleaks (8,9). A few reported cases have used NBCA in the treatment of type I endoleaks (9–11). In this study, we introduce a method of NBCA embolization using a percutaneous or a transarterial approach in cases in which exclusion of type I endoleaks by the universal methods of balloon PTA, stent-graft extension, or stent placement had failed.

MATERIALS AND METHODS

Patients

From 2001–2007, 12 patients underwent a second procedure to treat a persistent endoleak. Five patients underwent stent-graft extension ($n = 4$) or balloon angioplasty ($n = 1$), resulting in successful exclusion of the endoleak. The other seven patients (six men, one woman; age range 58–81 years, mean age 69.3 years) required embolization of the endoleak with NBCA because other endovascular treatment options had failed to exclude the endoleak. The failed endovascular options were balloon PTA ($n = 7$), Palmaz stent placement (Johnson & Johnson Interventional System, Warren, New York; $n = 1$, patient 5), and aortic extender cuff (stent-graft; Zenith, Cook, Inc, Bloomington, Indiana; $n = 2$, patients 5 and 6). Two of the seven patients (patients 5 and 6) had a sufficient margin for stent-graft extension. In patient 5, an aortic extender cuff and a Palmaz stent were placed. In patient 6, an aortic extender cuff was placed. The other five patients had no margin for placement of an aortic extender cuff for proximal type I endoleak, and no Palmaz stent was available, so balloon PTA was performed at the attachment site. These secondary endovascular interventions had failed to exclude type I endoleaks in all patients. Finally, an open surgical repair or embolization procedure was suggested for all patients. Because the general condition of these patients was unfavorable for major surgery and they refused surgical repair, embolization of the aneurysm sac was conducted after the failure of exclusion of type I endoleaks, despite the various attempts mentioned.

Combined coil embolization was necessary in three patients to obtain effective and safe exclusion of endoleaks in cases of high-flow massive endoleak from the attachment site and in cases in which the inferior mesenteric artery (IMA) acted as an exit route for the endoleak. NBCA embolizations were performed by percutaneous transabdominal or transarterial access routes. The site of endoleaks, risk factors of endoleaks, secondary interventions, and access route of NBCA embolization are summarized in **Table 1**.

N-Butyl Cyanoacrylate Embolization Procedure

The treatment protocol is summarized in **Figure 1**. For transarterial embolization, preembolization angiography was obtained, and selective catheterization of the aneurysm sac was performed by insertion of a 5-F catheter (Yashiro catheter, Terumo, Tokyo, Japan) between the aortic wall (type Ia) or iliac arterial wall (type Ib) and the stent-graft (**Fig 2a**). For cases in which the transarterial approach to the aneurysm sac was impossible, a percutaneous transabdominal approach was attempted. Before the procedure, intravenous prophylactic antibiotics (cefazolin 1 g [Yuhan Corp, Seoul, Korea] and tobramycin 100 mg [Daewoong Pharmaceutical Co, Seoul, Korea]) were given. Patients were placed in the supine position, and local anesthesia was administered. No other intravenous or endotracheal sedative was used. The target site of the puncture was identified as a contrast-enhancing area of the aneurysm sac by computed tomography (CT) scan (skin puncture point, puncture angle, and depth of aneurysm sac from the skin) and color-flow ultrasound (US) guidance. The aneurysm was punctured using a 21-gauge puncture needle (Chiba, Cook, Inc, Bloomington, Indiana). Bony landmarks and stent-graft marking bars were also referenced under fluoroscopic guidance. After confirmation of arterial blood flowing through the puncture needle, contrast medium was injected to visualize the aneurysm sac, 0.018-inch guide wire was inserted, and the puncture tract was dilated. Over 0.035-inch guide wire, a 5-F angiographic catheter was placed within the endoleak site, and an angiogram of the aneurysm sac was performed to evaluate the origin and outflow of the endoleak by the hand injection of the contrast medium (**Fig 3a**).

After accessing the aneurysm sac with a 5-F catheter by a transarterial or transabdominal approach, embolization of the aneurysm sac and outflow vessels was performed. A 2.8-F microcatheter (Progreat, Terumo, Tokyo, Japan) was used when a more advanced endoleak selection was necessary or when the selection of outflow vessels was attempted. Before injection of NBCA, the catheter was flushed with 5% dextrose in water solution to prevent precipitation of NBCA. NBCA liquid adhesive was mixed with iodized oil (Lipiodol Ultra Fluid, Guerbet, Aulnay-sous-Bois, France), 25%–50%, depending on the amount and velocity of blood flow from the endoleaks. When the