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Outcomes after celiac artery coverage during thoracic endovascular aortic aneurysm repair

Melanie K. Rose, MD, Benjamin J. Pearce, MD, Thomas C. Matthews, MD, Mark A. Patterson, MD, Marc A. Passman, MD, and **William D. Jordan, MD,** *Birmingham, Ala*

Objective: **Coverage of celiac artery (CA) during thoracic endovascular aortic aneurysm repair (TEVAR) has been performed to extend the distal seal zone for which preliminary results and short-term follow-up have been reported. We aim to show the outcomes up to 81 months after CA coverage during TEVAR.**

Methods: **Patients undergoing TEVAR with coverage of the CA origin from 2005 to 2013 were retrospectively analyzed. Points of analysis include indications for covering the CA, demonstration of collateral circulation between the CA and superior mesenteric artery (SMA), anatomic features of the distal landing zone, rate of reintervention, technical success, presence of clinical ischemic symptoms after the procedure, and mortality.**

Results: **During the 9-year period, 366 patients underwent TEVAR, 18 (5%) of whom had CA coverage. Eleven (61%) had TEVAR with CA coverage due to a thoracic aneurysm, three (17%) had thoracic aortic dissection related to aneurysm, and four (22%) had previous TEVAR with a type Ib endoleak (EL) requiring distal coverage. Mesenteric angiography in preparation for TEVAR with CA coverage diagnosed a critical SMA stenosis in one patient that was treated with stenting before the index procedure. At the conclusion of the indicated procedure, two patients (11%) had a type Ia EL and two patients (11%) had a type Ib EL. Three of the type I ELs required reintervention. Two patients (11%) had a type II EL, both of which were managed with observation and resolved. Reintervention was required in 27% of patients. Postoperative complications included visceral ischemia in 2 (11%), weight loss in 1 (5%), spinal cord ischemia in 2 (11%), a cerebrovascular event in 1 (6%), and death in 1 (6%). The mean follow-up period was 38 months (range, 0.5-81 months).**

Conclusions: **This analysis of outcomes up to 81 months supports the suitability of covering the CA in selected patients for extending the distal landing zone to the visceral aortic level above the SMA or when alternative branch vessel treatment is unavailable. Preoperative angiographic evaluation of the mesenteric collaterals and early postoperative surveillance may limit postoperative complications. Once the CA is covered, new symptoms do not develop unless the SMA is compromised. (J Vasc Surg 2015;62:36-42.)**

The management of complex thoracoabdominal aortic aneurysms with endovascular techniques has become the method of choice for repair in select patients. Aneurysms involving the infradiaphragmatic aorta pose a challenge to standard endografting due to the proximity of the mesenteric circulation. Branched, parallel, and fenestrated grafts have been used as alternatives to open repair. Such techniques involve significantly more time, expense, capital investment in imaging, and advanced endovascular skills to achieve reasonable outcomes.[1] An alternative technique for these complex repairs that only involves the proximal aspect of the paravisceral aorta is the intentional coverage of the celiac artery (CA) to extend the distal seal zone.[2]

CA coverage to obtain a distal seal during thoracic endovascular aortic aneurysm repair (TEVAR) is uncommon, with a reported occurrence of ~4.4%, as shown in 434 cases at six centers during a 7-year period.[3] In these situations, mesenteric angiography or computed tomography arteriography (CTA) with fine-cut multiplanar imaging is used for operative planning to ensure patency of a collateral circulation between the CA and superior mesenteric artery (SMA).[2] CA coverage has been demonstrated to be a safe and effective method, but as with other endovascular therapies, the long-term success of this technique is not known.[4] The purpose of this study was to evaluate the outcomes up to 81 months after CA coverage during TEVAR.

METHODS

Patients undergoing TEVAR with intentional coverage of the CA origin from 2005 to 2013 were identified from a prospectively maintained, computerized vascular surgery registry with a protocol of informed consent as approved by the Institutional Review Board. The patients entered into the analysis between March 2005 and May 2006 were previously evaluated with a short-term follow-up of

From the Division of Vascular and Endovascular Surgery, University of Alabama at Birmingham.

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Reprint requests: Melanie K. Rose, MD, Division of Vascular and Endovascular Surgery, University of Alabama at Birmingham, 1808 7th Ave S, BDB 503, Birmingham, AL 35294 (e-mail: mkrose@uabmc.edu).

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1 to 10 months.[2] The current analysis is a retrospective evaluation of the indications for covering the CA, demonstration of collateral circulation between the CA and SMA, anatomic features of the distal landing zone, rate of reintervention, technical success, presence of clinical ischemic symptoms over an extended period after the procedure, and mortality.

Primary technical success was defined as successful deployment of the endograft in the absence of surgical conversion to open repair, death ≤24 hours, type I or type III endoleak (EL), or graft obstruction as reported by the Society for Vascular Surgery (SVS) reporting standards.[5] Kaplan-Meier analysis was performed to plot survivability.

The practice of selecting patients for coverage of the CA vs open reconstruction evolved over time. Endovascular reconstruction with coverage of the celiac origin was advised for patients who were considered high risk for open thoracoabdominal reconstruction. More recently, techniques involving parallel grafts and complex fenestrated repair have been used for paravisceral thoracoabdominal aneurysms. The decision of the type of repair was left to the surgeon and varied according to each clinical circumstance.

A selective mesenteric angiogram was performed preoperatively or at the index operation to assess collateral circulation and aberrant anatomy between the CA and the SMA. This also provided an analysis of the additional sealing zone that might be obtained from coverage of the CA and evaluated the caliber of the SMA. When angiography did not demonstrate a collateral vessel between the CA and SMA, the preprocedural CTA and postdeployment angiography were reviewed to ensure a patent collateral network. If this was not evident, the patient was considered for parallel, branched graft, or fenestration. A balloon occlusion test of the CA was not routinely performed.

Operative procedures were performed under general anesthesia. Spinal drains were selectively placed according to our institutional protocol.[6] Patients were assessed postoperatively in the surgical intensive care unit for 24 to 48 hours for signs and symptoms of visceral ischemia or paralysis. This included monitoring for abnormal vital signs, abdominal pain, nausea or vomiting, and neurologic assessment. Laboratory analysis included a complete blood count, basic metabolic panel, and coagulation panel. Hepatic function panel and serum lactic acid concentration were not routinely obtained.

Follow-up consisted of radiographic imaging and physical examination at 1, 6, and 12 months and then yearly thereafter. Abdominal vascular duplex ultrasound imaging was performed if abdominal symptoms were elicited at clinic follow-up. Imaging studies were reviewed for device migration, sac size, EL, or SMA compromise.

RESULTS

During the 9-year period, 10 patients had open thoracoabdominal aortic aneurysm repair, 7 underwent debranching (none of which included the CA), and 366 had TEVAR. Of the 366 patients that underwent TEVAR, eight (2%) had CA snorkel, and 18 (5%) had intentional CA coverage.

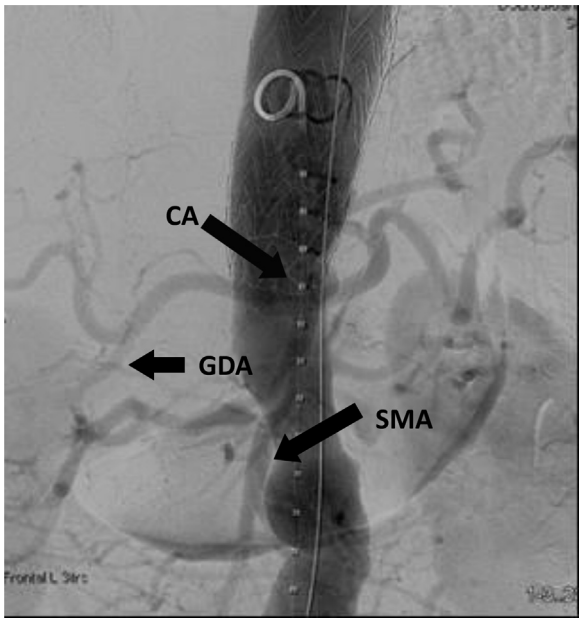

Fig 1. Postdeployment angiogram shows placement of a 34- × 15-mm endograft at the celiac artery (*CA*) origin, with collateralization from the superior mesenteric artery (*SMA*) and no evidence of endoleak (EL). *GDA,* Gastroduodenal artery.

In the CA coverage group, the mean ± standard deviation patient age was 69 ± 9.5 years. The mean aneurysm size was 67.4 ± 1.1 mm, as documented by preoperative CTA. Technical success was 78% due to four patients that had type I ELs. Eleven patients (61%) had TEVAR with CA coverage due to primary thoracic aneurysms, including one rupture. Three patients (17%) had thoracic aortic aneurysm related to dissection. Four patients (22%) previously underwent TEVAR and developed type Ib ELs requiring distal coverage. Seventeen patients demonstrated collateral circulation through the gastroduodenal artery between the CA and SMA before deployment of the stent graft. The one patient who did not have a predeployment angiogram showing collaterals had a postdeployment angiogram showing collateral flow to the celiac branches, and a postoperative CT showed retrograde hepatic flow filling from the SMA (Figs 1 and 2). Another patient's preoperative angiography demonstrated severe SMA stenosis that was treated with stenting 3 days before TEVAR with CA coverage, without any evidence of ischemic sequelae.

During the follow-up period, EL developed in four patients: two patients (11%) had a type Ia EL, two different patients (11%) had a type Ib EL related to inadequate sealing at the SMA origin, and three of these patients required intervention. The first patient demonstrated a type Ia EL 2 months after TEVAR. This patient was a 53-year-old man who presented with acute ascending aortic dissection that required arch reconstruction with an elephant trunk procedure, with TEVAR and CA coverage as the second