to be present for open repairs (69.1%) than EVARs (59.7%, $P < .001$; Fig 1). In nonruptured cases, the overall mortality rate was 1.6% and much higher with open than with EVAR (9.3% vs 1.4%, $P < .001$). Complication rates and mortality rates, however, were unaffected by trainee involvement in nonruptured EVAR (12% and 1.4%; $P = .69$ and $P = .20$, respectively) and with ruptured EVAR (50.8% and 21% vs. 28%, $P = .91$ and $P = .06$, respectively). On multivariate analysis, rupture was associated with a 2.5-fold increased risk of complication and 4.1-fold risk of death ($P < .001$). EVAR had a protective effect (0.313, 0.396; $P < .001$). Resident involvement had no effect on mortality ($P = .45$) but was associated with a protective effect (0.702; 95% confidence interval, 0.57-0.86; $P = .001$). With elective cases, mean operative time for EVAR was 155.6 minutes and was 23 minutes longer with a trainee involved in the case ($P < .001$). Open repair averaged 267 minutes and was 41.8 minutes longer with trainees ($P = .052$; Fig 2).

Conclusions: Current trends for abdominal aortic aneurysm repair reveal an expected but remarkable increase in EVAR and higher mortality rates in open repair than historical series. Trainee involvement was associated with increased operative time and lower mortality in ruptured EVAR.

Emboli Arising From Mural Thrombus on Dacron Grafts After Open Repair of Traumatic Thoracic Aortic Injury

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Objective: Thoracic aortic thrombus is rare and can cause visceral and lower extremity thromboemboli. Thrombus of the thoracic aorta has been associated with atherosclerotic disease, hypercoagulable states, steroid therapy, tumors, and aortic injury. There is no consensus on therapy. Thrombus on a Dacron interposition graft (DIG) after reconstruction of the thoracic aorta for blunt thoracic aortic injury (BTAI) has not been described. We present two patients whom we treated with thoracic aortic stent endografts and anticoagulation.

Methods: Patient 1 is a 27-year-old man who presented with abdominal pain, nausea, vomiting, and claudication. He sustained a BTAI in a motor vehicle crash 19 months prior, which was repaired with a DIG in the proximal descending thoracic aorta. His workup revealed ulcerated mural thrombus in the thoracic aortic graft (Fig, *A*), with emboli to the superior mesenteric artery (Fig, *B*) and lower extremities. Patient 2 is a 42-year-old man who developed sudden abdominal pain 17 years after a motor vehicle accident with a BTAI repaired with a DIG. His workup showed pedunculated mural thrombus in the thoracic aortic graft (Fig, *D*), with emboli to the spleen (Fig, *E*) and right kidney.

Results: In patient 1, by way of a conduit sewn to the distal aorta exposed with a retroperitoneal approach, a Talent thoracic endograft was deployed across the DIG, covering the thrombus. The superior mesenteric artery embolism was treated with catheter-directed thrombolysis, and the occluded lower extremity arteries were bypassed (Fig, *C*). Warfarin anticoagulation was initiated. Because of poor outflow, he required a left below knee amputation at 3 months. He is doing well at 3 years. In patient 2, A Cook TX2 endograft was deployed across the thrombus. Warfarin anticoagulation was initiated, with no further emboli at 5 months.

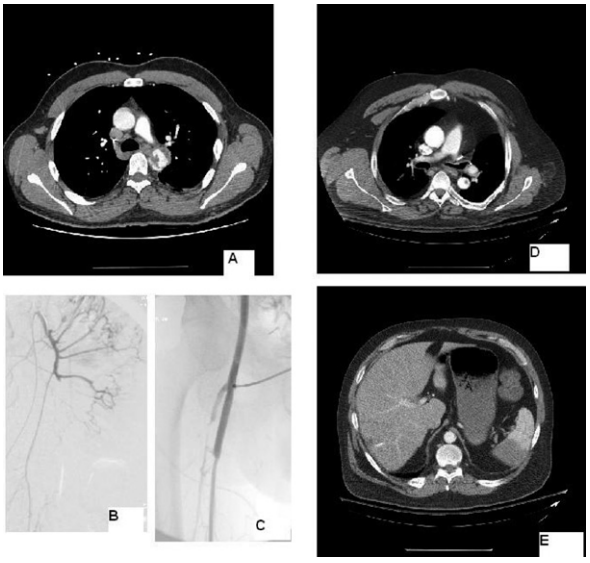

Fig.

Conclusions: Thromboembolization after open repair of BTAI has not been described. Most patients with traumatic injuries lack long-term follow-up; the true incidence of this complication is unknown. Although anticoagulation alone has successfully treated embolizing thoracic aortic thrombus, recurrent emboli can be devastating. Endografts can prevent recurrent emboli, but risk intraprocedural emboli. When deploying the stent graft, manipulation of wires and catheters should be minimized and postdilation avoided. Adjuvant anticoagulation was used to prevent future thrombus because the cause of thrombus formation was unclear.

Aortic Diameter Varies in Trauma Patients: A Function of Hemodynamic Status

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Objective: Accurate aortic measurements necessary for optimal endovascular aortic aneurysm repair and thoracic endovascular aortic repair can be affected by hemodynamic alterations. We analyzed aortic morphology in trauma patients during and after resuscitation to determine the association of diameter differences with hemodynamic status.

Methods: An Investigational Review Board-approved query of a level I trauma registry identified all patients from 2008 to 2009 with aortic computed tomography angiography (CTA) imaging on admission. Follow-up CTA imaging during the same hospitalization or in the midterm follow-up were compared. Orthogonal diameters were measured at four standardized levels: at the takeoff of the innominate, distal to the left subclavian, at the diaphragm, and at the celiac axis.

Results: Of 979 trauma patients with admission aortic CTAs, 115 (69% men; average age, 47 years; average injury severity score [ISS], 17) also had follow-up CTAs after resuscitation to constitute the study population. Average admission aortic diameters were 28.9 (innominate), 25.6 (distal to the subclavian), 21.7 (diaphragm), and 20.3 mm (celiac axis), Hemodynamic instability, defined as systolic blood pressure of 110 mm Hg or mean arterial pressure <70 mm Hg, was present in 29 patients (25%) with a mean ISS of 27 ($P < .001$). The remaining 86 hemodynamically stable patients had a mean ISS of 12.0 ($P < .001$). On follow-up CTA (median time to second CTA was 96 hours), significant differences in aortic diameters were found at each level in all hemodynamically stable and unstable patients combined, with a mean change of +5.5% at the innominate, +8% distal to the left subclavian, +5.4% at the diaphragm, and +4.5% at the celiac trunk when compared with the admission CT imaging (all $P < .001$). In the hemodynamically unstable patients, the follow-up aortic diameters demonstrated an even larger change at each level compared with hemodynamically stable patients (Fig).

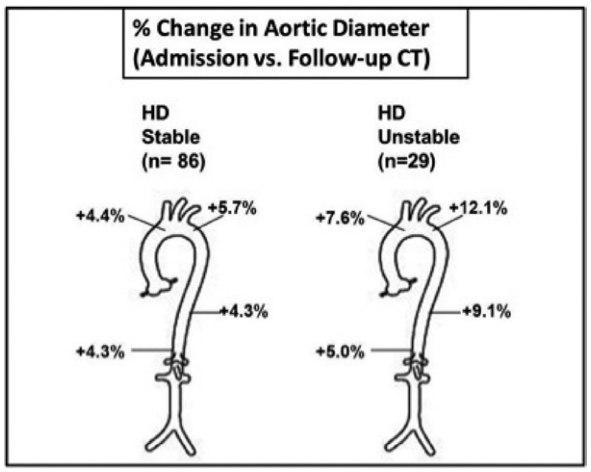

Fig.

Conclusions: Significant differences exist between measurements taken at standardized locations of the aorta in trauma victims before and after their initial resuscitation. Worsening hemodynamics accentuate these differences and can have important implications for endograft sizing. The timing of the CTA performed during a trauma patient's workup and the expected diameter increases should be taken into consideration for

appropriate oversizing of endografts during endovascular repair of traumatic injury and thoracic endovascular aortic repair planning and execution.

Midterm Outcome of Endovascular Repair of Ruptured Abdominal Aortic Aneurysm: What Happened to Patients That Survive?

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Objective: Operative outcomes are improved in patients with a ruptured abdominal aortic aneurysm (rAAA) who undergo endovascular repair (rEVAR) compared with open surgical repair. Follow-up of these patients, however, is lacking. We aim to characterize the midterm outcome of rAAA patients who have been managed with endovascular techniques compared with open surgical repair.

Methods: In an Investigational Review Board-approved prospective study, we evaluated all patients with rAAA admitted from July 2007 to February 2012 who survived to hospital discharge. Linear regression and multivariable analysis models were used to evaluate outcome data, including hospital length of stay, destination at discharge, survival, type of surgical procedure, presence of hypotension, and demographics.

Results: A total of 118 patients were admitted to our facility with the diagnosis of rAAA. Eight underwent comfort care, and four died in the operating room before repair. Of the remaining 106 patients, 43 had open repair and 63 were done with endovascular technique. Seventy-two patients survived to discharge, with 21 of 43 (48%) in the open surgical group and 51 of 63 (81%) in the endovascular group. Average length of stay was 12.3 days for the endovascular group and 24.6 days for the open group ($P = .002$). Of the 72 patients who survived to discharge, 37 (51%) went home and 35 (49%) were discharged to a skilled nursing facility. Of the 51 endovascular patients, 33 (65%) were discharged to home vs four of 21 (19%) in the open repair group. Twenty patients died after being discharged from the hospital, of whom, seven died ≤30 days after discharge. Overall, the follow-up rate was 72% (59 of 72), with 13 patients lost to follow-up with an average length of follow-up of 22.8 months. Multivariable regression analysis showed that only the type of procedure performed (endovascular) was predictive of the discharge destination. Survival at midterm follow-up was independent of type of procedure performed and discharge destination.

Conclusions: The introduction of rEVAR has resulted in improvement of the in-hospital survival of patients with rAAA, with more patients able to be discharged to home compared with those undergoing open surgical repair. At midterm follow-up, however, the survival rate of rAAA patients was comparable between rEVAR and open surgical repair.

Ten-Year Results of Endovascular Abdominal Aortic Aneurysm Repair (EVAR) from a Large Multicenter Registry

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Objective: This study assessed long-term outcomes after endovascular aneurysm repair (EVAR) in an integrated health care system.

Methods: Between 2000 and 2010, 1736 patients (86% were men) underwent EVAR at 17 centers. Demographic data, comorbidities, and outcomes of interest were collected. Primary outcomes were mortality and aneurysm-related mortality (ARM). Secondary outcomes were change in aneurysm sac size, endoleak status, major adverse events, and reintervention.

Results: Overall, mean age was 75 years, 82% were Caucasian, and 90% of cases were elective. Urgent use of EVAR increased from 7% in the first 5 years to 12% in the latter 5 years of the study. Mean aneurysm size was 5.8 cm. Patients were monitored for an average of 3 years (range, 1-11 years); 8% were lost to follow-up. Intraoperatively, 5% of patients required adjunctive maneuvers for endoleak, fixation, or flow-limiting issues. The 30-day mortality rate was 1.2%, and the perioperative morbidity rate was 6.6%. Intraoperative type I and II endoleaks were uncommon (2.3% and 9.3%, respectively.) Life-table analysis at 5 years demonstrated excellent overall survival of 66% and freedom from ARM of 97%. Postoperative endoleak occurred in 30% of patients and was associated with an increase in sac size over time (Fig). Finally, the total reintervention rate was 15%, including 91 (5%) revision EVARs. The overall major adverse event rate was 8% and decreased significantly from 12.3% in the first 5 years to 5.6% in the second 5 years of the study ($P < .001$). Overall, ARM was worse in patients with postoperative endoleak (4.1% vs 1.8%, $P < .01$) or undergoing reintervention (7.6% vs 1.6%, $P < .001$).

Conclusions: Results from a real-world EVAR registry in an integrated health care system demonstrate favorable perioperative outcomes and excellent long-term clinical efficacy. However, postoperative endoleak and need for reintervention continue to be challenging problems for patients after EVAR.

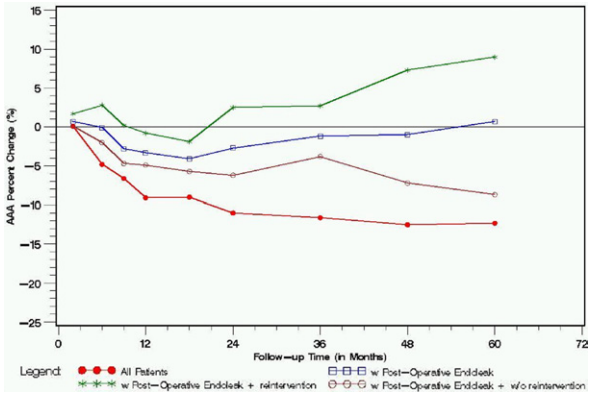

Fig.

Intraprocedural and Postprocedural Transarterial Sac Embolization for Type II Endoleak

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Objective: Persistent type II endoleaks (T2E) affect up to one-third of patients undergoing endovascular aneurysm repair (EVAR), and one-third or more of these patients will require intervention. We present a novel technique available intraprocedurally and postprocedurally to prevent or treat persistent T2E.

Methods: This cohort represents a single-center and single-surgeon experience where transarterial sac embolization (TASE) for T2E was performed. Patients, upon completion angiogram for EVAR with a large T2E or for T2Es noted on surveillance computed tomography scan with enlarging aneurysms, underwent placement of a catheter beyond the iliac limb of a deployed endograft from groin access. Contrast was then infused into the sac to corroborate the presence of a T2E, and subsequently, a thrombin and Gelfoam slurry with contrast was infused into the aneurysm sac. Since 2006, 13 patients have undergone TASE for intraprocedural and postprocedural T2E.

Results: Eight patients (61.5%) underwent intraprocedural TASE and five (38.5%) underwent postprocedural treatment. The median follow-up was 12 months (range, 0.0-51.3 months); 11.0 months for the intraprocedural arm (range, 0.5-30.6 months) and 13.6 months (range, 0.0-51.3) for the postprocedural group. No patients had further growth of their aneurysm. Three patients (23.1%) had stable aneurysm size, seven (53.8%) had a decrease in aneurysm diameter, one patient had continued aneurysm growth but had a type IV endoleak upon re-exploration, one patient had a recent TASE, and one patient was lost to follow-up. No spinal embolization, distal embolization, ruptures, or systemic complications occurred during TASE.

Conclusions: We present an innovative technique of sac access and embolization during and after EVAR placement to treat intraprocedural and postprocedural endoleaks. Further study is required to evaluate the safety, efficacy, and potential cost-savings.

Failure to Prevent Aneurysm Rupture Despite Early Diagnosis

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Objective: Screening and surveillance is paramount in the management of small abdominal aortic aneurysms (AAA). Gaps in surveillance after early diagnosis may lead to unrecognized AAA growth, rupture, and death. This study investigates the prevalence and factors associated with rupture of previously diagnosed AAA.

Methods: Data were extracted from Medicare claims for patients who underwent AAA repair from 2006 to 2009. All relevant preoperative abdominal imaging examinations were tabulated 5 years before AAA repair. Repair for ruptured AAA was compared with repair for intact AAA for those with early diagnosis, which was defined as at least one image more than 6 months before surgery. Gaps in surveillance were defined as no image ≤1 year of surgery or no imaging for >2-year time span. Hierarchic logistic regression was used to examine independent predictors of rupture despite early diagnosis.

Results: Of 15,770 patients who underwent AAA repair, 1272 (8.1%) had repair after rupture. Of those with ruptured AAA, 34.7% had abdominal imaging >6 months before rupture, compared with 61.1% for intact repair. For patients with early diagnosis, those with ruptured AAA were older (80.2 ± 6.9 vs 77.6 ± 6.2 years, $P < .0001$), received fewer images before repair (5.7 ± 4.1 vs. 6.5 ± 3.5, $P = .0001$), were less likely to be treated in a high-volume hospital (45.4% vs 59.5%, $P < .0001$), and were more likely to have had gaps in surveillance (47.4% vs 11.8%, $P < .0001$) compared with those with intact repair. After adjusting for medical comorbidities, gaps in surveillance remained the strongest predictor of rupture by multivariate analysis (odds ratio, 5.97; 95% confidence interval, 4.77-7.48; $P < .0001$; Table).