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Application of endograft to treat thoracic aortic pathologies: A single center experience

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Purpose: **To evaluate our experience of thoracic endoluminal graft (ELG) repair of various thoracic aortic pathologies using a commercially available device approved by the Food and Drug Administration. Our patient population includes patients eligible for open surgical repair and those with prohibitive surgical risk.**
Methods: **From March 1998 to March 2006, endovascular stent repair of the thoracic aorta was performed on 406 patients with 324 patients (median age 72; 200 male) receiving the Gore Excluder endograft. Patient demographics, procedural characteristics, complications, including endoleak, spinal cord ischemia, and mortality, were retrospectively reviewed during follow-up. All patients were followed with chest computer tomography at 6 months and yearly. Statistical analysis was performed utilizing the SPSS Windows 11.0 program. Logistic regression (univariate) analysis used to identify risk factors for paraplegia; analysis of variance (ANOVA) for endoleak distribution; and χ^2 used to analyze variables. Survival analysis was done using SAS version 9.1 (SAS Institute, Cary, NC).**
Results: **Three hundred twenty-four patients were treated with Gore Excluder graft between March 1998 and March 2006. One hundred fifty-seven patients (48.5%) had atherosclerotic aneurysms, 82 (25.3%) had dissections type B (DTB), 34 (10.5%) had penetrating ulcers (PU), 26 (8.0%) with pseudoaneurysms (PSA), 11 (3.4%) had transections (MVAT), 9 (2.8%) aorto-bronchial fistulas (AoBF), 4 (1.2%) embolization, and 1 (0.3%) aorto-esophageal fistula (AoEF). Preoperative aneurysm sac size in TAA ranged from 5 to 12 centimeters, average size 6.3 cm. Sac shrinkage occurred in 65% (102 of 157) of patients. Average postoperative sac size of 5.4 cm in a mean follow-up of 20.4 months. One hundred cases (31.5%) were nonelective; 49 (15.1%) were ruptures. Overall complication was 22.7%, 14.2% (46) in elective cases and 8.5% (28) in nonelective cases. Paraplegia occurred in five (1.5%) patients and paresis in three (0.9%); two of the latter improved and one resolved completely prior to discharge. Incidence of paraplegia was statistically significant (P value < .05) with retroperitoneal approach, perioperative blood loss greater than 1000 cc, and aortic coverage greater than 40 cm. Early endoleaks included 18 (5.5%) type I, four (1.2%) type II, and two (0.6%) type III. Thirty-day mortality was 5.5% (18 related deaths, including three intraoperative deaths). A log rank test did not find statistical differences in actuarial survival with 30-day related mortality between TAA and other pathologies (P = .29) or between DTB and other pathologies (P = .97). Late mortality was 9.6% with 31 unrelated deaths. Follow-up ranged between 1 month and 70 months, average 17 months.**
Conclusions: **Endoluminal grafting is a feasible alternative to open surgical repair for thoracic aortic pathologies. After more than 300 cases, 30-day morbidity and mortality compares favorably with open repair. Paraplegia remains low as a complication and increases in incidence with retroperitoneal approach, increased perioperative blood loss, and increased aortic coverage. (J Vasc Surg 2007;46:413-20.)**

Surgical treatment of the thoracic aorta can be challenging to the surgeon due to the potential perioperative morbidities. With more complex thoracic aortic pathology, difficult anatomy, and less than fit patients, these morbidities increase. Surgical morbidity is significant and may include stroke, myocardial infarction, pulmonary insufficiency, renal insufficiency/failure and paralysis.[1-5] Paraplegia for an isolated descending thoracic aneurysm is as much as 4%.[6]

Endoluminal stent grafting (ELG) has been recently considered a possible alternative. Initial series documented comparable morbidity and mortality to that of open repair.[7-18] Paraplegia, one of the most devastating complications, seemed less prevalent. The US nonrandomized clinical controlled trial with the Gore-Tag device (W. L. Gore, Flagstaff, Ariz) comparing the ELG vs open repair led to the approval of the endograft to be used in descending thoracic aneurysms. This trial demonstrated advantages over the open cohort when 30-day mortality and paraplegia were considered.[19] More recent series reviewing early results indicate that this is a feasible option for patients not only with atherosclerotic aneurysms but with a variety of other thoracic aortic pathologies, however, long-term benefits have yet to be proven.[20-26] We report a single center experience using the Gore Excluder/Tag graft to treat various thoracic aorta pathologies; early and late follow-up are included.

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METHODS

Between March 1998 and March 2006, 406 patients were treated with an endoluminal graft at the Arizona Heart Hospital. Of these patients, 324 patients (median

Table I. Comorbidities and risk factors

HTN	282 (87.0%)	ESRD	4 (1.2%)
CAD	116 (35.8%)	Obesity	17 (5.2%)
PVOD	123 (38.0%)	Hemoptysis	3 (0.9%)
DM	34 (10.5%)	AAA repair, prior	20 (6.2%)
COPD	142 (43.8%)	Tobacco use	197 (60.8%)
CVD	32 (9.9%)	Assoc. trauma	24 (7.4%)
Renal insuff	54 (16.7%)		

HTN, Hypertension; *CAD,* coronary artery disease; *PVOD,* peripherovascular disease; *DM,* diabetes mellitus; *COPD,* chronic obstructive pulmonary disease; *CVD,* cerebrovascular disease; *ESRD,* end stage renal disease; *AAA,* abdominal aortic aneurysm.

age 72; 200 male) were treated with the Excluder/Tag device to manage 157 (48.5%) aneurysms (TAA), 82 (25.3%) type B dissections (DTB), 34 (10.5%) penetrating ulcers (PU), 26 (8%) pseudoaneurysms (PSA), 11 (3.4%) aortic transections, 9 (2.8%) aortobronchial fistulas, 4 (1.2%) embolization, and 1 (0.3%) aorto-esophageal fistula. Prior to Food and Drug Administration (FDA) approval, all patients were enrolled under the guidelines of the FDA Investigational Devices Exemption (IDE) for the Gore Excluder or Gore-Tag (W. L. Gore, Flagstaff, Ariz) specifically granted to our institution and in compliance with the Institutional Review Board of the Arizona Heart Hospital.

The Gore Excluder/Gore-Tag is a self-expandable endograft composed of an expanded polytetrafluoroethylene (ePTFE) tube and external nitinol support system designed for the thoracic aorta. It is mounted in a flexible delivery system. A pull string releases the graft, deploying from the middle of the graft to each end. A trilobular balloon can be used to further expand the graft post deployment.

Each patient was examined and preoperative studies, including carotid/vertebral artery duplex and CT of the chest with and without IV contrast, were reviewed (Table I). It is then determined if more proximal coverage is necessary to prevent type I endoleak. If there is a dominant left vertebral artery, patent internal mammary artery, or concern for postoperative paraplegia (ie, extensive aortic coverage), left subclavian artery (SCA) revascularization was performed. Measurements were taken from the CT-scan and perioperative intravascular ultrasound (IVUS), and an appropriate endoluminal graft was selected based upon these measurements and anatomic features. All devices were oversized by at least 2 mm in reference to the neck diameter.

All procedures were performed in the endovascular/surgical suite under general anesthesia. Open exposure of the common femoral artery with the least calcific external and common iliac arteries was done, meanwhile percutaneous access at the contralateral groin and placement of a 5F sheath was completed. Those with severely diseased iliac arteries received an iliofemoral conduit through a retroperitoneal approach with deployment of the graft via that conduit (10 mm Dacron tube-graft). Percutaneous brachial access was obtained as necessary depending upon involvement of the aortic arch.

Transesophageal echocardiography (TEE) was implemented in complicated dissections or pathologies involving the more proximal arch. The selected device was advanced via a Gore sheath (W. L. Gore, Flagstaff, Ariz), a Keller-Tillerman introducer sheath (Cook, Inc, Bloomington, Ind), or bare-back with the delivery system alone dependent upon the anatomic constraints of each case.

Statistical analysis was performed utilizing the SPSS Windows 11.0 program. Logistic regression (univariate) analysis used to identify risk factors for paraplegia; analysis of variance (ANOVA) for endoleak distribution; and χ^2 used to analyze variables. Survival analysis (Log rank test) was done using SAS version 9.1 (SAS Institute Cary, NC). A P value $< .05$ was considered statistically significant.

RESULTS

Between March 1998 and March 2006, 406 patients at Arizona Heart Hospital were treated for a thoracic pathology using endoluminal grafting and 324 were treated with a Gore endoluminal graft. Of the patients, 200 were male (61.7%) with a mean age of 72-years-old (range 16 to 91). The majority of patients were treated for aneurismal disease (48.5%) and dissections (25.3%) (Table II). Of 324 patients, 204 (65.1%) required a single graft to correct the pathology, but three or more grafts (24, 7.4%) were placed in others (Table III). More than 40 centimeters of the descending thoracic aorta was covered in 33 patients (10%). Preoperative aneurysm sac in TAA ranged from 5 to 12 cm, average size 6.3 cm. Sac shrinkage occurred in 65% of patients (102/157). Average postoperative sac size of 5.4 cm with a mean follow-up of 20.4 months (3 to 60 months).

Additional procedures were necessary at the time of deployment. Thirty-seven (10.9%) patients (28 females) required an iliofemoral conduit via a retroperitoneal approach to facilitate access and introduce the device. Thirty-seven (10.9%) patients had the left SCA covered or coiled in order to gain length proximally for anchoring. Thirteen (4%) underwent a carotid-subclavian bypass. When the decision was made for left SCA revascularization, the proximal SCA was ligated. However, if the SCA was covered and a type II endoleak persists, coil embolization was done. Eight (2.5%) patients underwent thoracic debranching, and the same number underwent abdominal debranching. Seven (2.2%) patients underwent perioperative repair of their abdominal aortic aneurysm with endoluminal grafting (Table IV). The mean operating room time was 1.75 hours (range 0.75 to 6.25). The median estimated blood loss of 200cc, range 50 to 3500cc. Median length of stay was 4 days (range 1 to 40 days).

One hundred cases (31.5%) were nonelective, 49 (15.1%) were ruptured. A nonelective case was defined as a rupture or contained rupture of an aneurysm, pseudoaneurysm, or penetrating ulcer. In addition, any patient who was hemodynamically unstable with evidence of hypovolemic shock, intractable pain, or malperfusion of viscera or limbs was considered emergent.

Table II. Aortic pathologies, age, gender, and nonelective status

	N (%)	*Age mean/range*	*Male (%)*	*Female (%)*	*Nonelective status (%)*
TAA	157 (48.5)	70.5 (35-93)	87 (55)	70 (45)	24 (15.2)
DTB	82 (25.3)	65.3 (43-88)	62 (76)	20 (24)	31 (37.8)
PU	34 (10.5)	74.9 (52-91)	18 (53)	16 (47)	20 (58.8)
PSA	26 (8.0)	63.5 (27-84)	16 (62)	10 (38)	8 (30.7)
MVAT	11 (3.4)	47.2 (16-74)	9 (82)	2 (18)	10 (90)
AoBF	9 (2.8)	76.5 (52-77)	6 (66)	3 (34)	6 (66.6)
Emboli	4 (1.2)	76.7 (30-75)	1 (25)	3 (75)	0
AoEF	1 (0.3)	54	1 (100)	0	1 (100)
Total	324 (100)	72	200 (61.7)	124 (38.3)	100 (31.5)

TAA, Thoracic aortic aneurysm; *DTB,* dissection type B; *PU,* penetrating ulcer; *PSA,* pseudoaneurysm; *MVAT,* motor-vehicle accident transaction; *AoBF,* aorto-bronchial fistula; *Emboli,* embolization; *AoEF,* aortoesophageal fistula.

Table III. Total number of grafts per pathology

	Total endografts				
	1	*2*	*3*	*4*	*Total*
Aneurysm	89	52	14	2	157
Pseudoaneurysm	24	1	1	0	26
Penetrating ulcer	31	3	0	0	34
Dissection	46	29	6	1	82
Transection	10	0	1	0	11
Embolization	4	0	0	0	4
Aortobrochial fistula	5	4	0	0	9
Aortoenteric fistula	0	1	0	0	1
Total	209	90	22	3	324

Overall morbidity was 22.7%. The most common complications included respiratory failure (defined as intubated > 72 hours) 19 (5.9%), limb ischemia 9 (2.8%), renal failure (hemodialysis) 7 (2.2%), cerebrovascular accident 7 (2.2%), bowel ischemia 5 (1.5%), and 4 (1.2%) myocardial infarctions. Migration occurred in one (0.3%) patient following treatment of an Ao-EF. During the intervention, thoracic aortic rupture occurred in four (1.2%) patients, two (0.6%) underwent open conversion. AAA rupture occurred in three (0.9%) patients, two during thoracic intervention, and iliac rupture in five (1.5%) (Table V). Paraplegia occurred in five (1.5%) patients and paresis in three (0.9%), two of the latter improved and one resolved completely prior to discharge. Incidence of paraplegia was statistically significant (*P* value < .05) with retroperitoneal approach, perioperative blood loss greater than 1000 cc, and aortic coverage greater than 40 cm. Other variables evaluated included age (0.291), gender (0.167), pathology (TAA-0.458, DTB-0.899), rupture (0.999), left SCA coverage (0.118), and previous abdominal aortic coverage (0.999).

Of those with paraplegia, four of the five received spinal drains. Sensation improved in one of the four patients, but function did not return to any. Three of the five patients died, one at 2 days secondary to suspected pulmonary embolism, one at 5 days due to intracerebral bleeding (ICB) with herniation, and one within 30 days due to multisystem organ failure. Of the three patients with paresis, the one with paraparesis received a spinal drain: symptoms completely resolved in one leg and improved significantly in the other. The other two had monoparesis, one resolved completely and the other improved significantly with induced hypertension alone.

Of those seven patients who suffered a CVA, four of the patients had been treated for dissection (two emergent) and the remaining three treated for aneurismal disease (one emergent). Two patients had previous stroke. Five of the seven improved the symptoms during the postoperative period. One patient had CVA secondary to major ICB (Table V).

Early endoleaks included 18 (5.5%) type I, four (1.2%) type II, and two (0.6%) type III. Incidence of endoleak in elective interventions was 5.6% and that in nonelective procedures was 6.0%, (no statistical significance, $P > .05$) (Table VI). Twelve of 18 (65%) of the type 1 endoleaks occurred with thoracic aortic aneurysms. No intervention in 15 (six of them type I) of 24 endoleaks (62.5%). Of the six untreated type 1 endoleaks, each with small, distal endoleak, four resolved without intervention and two remain unchanged (one patient with chronic renal failure). Of those 15 untreated endoleaks, five (three type 1) died within the immediate postoperative period to causes not associated with the endoleak. Of the remaining nine type 1 endoleaks, eight received additional ELG and one balloon angioplasty alone; of these, one had a large persistent proximal type 1 endoleak treated with open conversion. Re-intervention related to management of early endoleaks involved deployment of an additional endoluminal graft in 11 patients, stenting in three patients, and coil embolization in one patient (Fig 1).

Late complications included eight (2.5%) type I endoleaks, three (0.9%) type II endoleaks, and two type III endoleaks. Management of late endoleaks included coil embolization of intercostal branches in two patients, additional ELG in six cases, and aortic arch debranching in one patient (Table VII).

Thirty-day mortality was 5.5% (18 related deaths, including three intraoperative deaths). A log rank test did not find statistical differences in actuarial survival with 30-day related mortality between TAA ($P = .29$) or between DTB ($P = .97$) and other pathologies (Figs 2 and 3). Late mortality was 9.6% with 31 unrelated deaths. Unrelated late

Table IV. Adjunctive procedures

	Total									
	Carotid-subcl bypass	*Subcl embolization*	*Subcl ligation/cover*	*Sac embolization*	*AAA elg*	*AAA repair*	*Retroper approach*	*Thor debranching*	*Abd debranching*	
Aneurysm	7	2	18	0	2	2	27	4	8	157
Pseudoaneur	1	0	2	0	1	0	3	2	0	26
Pene ulcer	0	0	0	0	0	0	3	0	0	34
Dissection	4	1	11	2	4	1	3	2	0	82
Transection	0	0	0	0	0	0	0	0	0	11
Embolization	0	0	0	0	0	0	0	0	0	4
Aortobrochial fistula	1	0	3	0	0	0	1	0	0	9
Aortoenteric fistula	0	0	0	0	0	0	0	0	0	1
Total	13	3	34	2	7	3	37	8	8	324

Subcl, Subclavian; *AAA,* abdominal aortic aneurysm; *elg,* endoluminal graft; *retroper,* retroperitoneal; *thor,* thoracic; *abd*, abdominal; *pene*, penetrating.

Table V. Overall complications

	Total N/%	*Elective N/%*	*Nonelective N/%*
Resp failure	19/5.9%	8/3.5%	11/11.0%
Limb ischemia	9/2.8%	7/3.1%	2/2%
Renal failure	7/2.2%	4/1.7%	3/3%
CVA	7/2.2%	4/1.7%	3/3%
Bowel ischemia	5/1.5%	3/1.3%	2/2%
Myocardial infarction	4/1.2%	3/1.3%	1/1%
Graft migration	1/0.3%	0	1/1%
TA rupture	4/1.2%	2/0.8%	2/2%
AAA rupture	3/0.9%	3/1.3%	0
Iliac rupture	5/1.5%	4/1.7%	1/1%
Paraplegia	5/1.5%	4/1.7%	1/1%
Paresis	3/0.9%	2/0.8%	1/1%
Open conversion	2/0.6%	2/0.8%	0
Total	74/22.7%	46	28

HD, Hemodialysis; *CVA,* cerebrovascular accident; *TA,* thoracic aorta; *AAA,* abdominal aortic aneurysm.

mortality of TAA ($P = 0.52$) and DTB ($P = .97$) did not show statistical difference when compared to other pathologies (Figs 4 and 5). Mortality rate with elective procedures was 4.9% (11 in 224) and 7% (7 in 100) for nonelective procedures. Follow-up ranged between 1 and 70 months, average of 17 months.

DISCUSSION

During this past decade, there has been increasing interest in the use of endoluminal stent grafts as an alternative treatment for various thoracic aortic pathologies. Endoluminal therapy has been documented to have less morbidity and mortality when compared with conventional open thoracic aortic repair. Morbidity and mortality of open repair has been estimated as high as 20%, with most estimating the risk of paraplegia at 4%.[6] Several studies have reviewed thoracic endoluminal grafting for acute and elective cases.[8-18,21,27-29] Most of these series consists of a small number of patients, with as many as 125 patients and mean follow-up between 11 and 35 months. Although these series were small, the results were encouraging. Mortality ranged from 0% to 10%, total morbidity was as high as 30%, with the incidence of paraplegia between 0% and 12.5%, mean 3.4%. The occurrence of endoleak was between 0% and 25%, with a mean of 10.6%.

In our series, we reviewed 324 patients who underwent endografting of the thoracic aorta utilizing the Gore-Excluder and Gore-Tag device. Overall morbidity was 22.7% with 2.4% spinal cord ischemia (paraplegia and paresis). One of the most dramatic observations is the reduced incidence of paraplegia and paresis. We found the incidence of paraplegia to be 1.5% and paresis 0.9%, which is considerably less than that associated with open thoracic repair.

The occurrence of paraplegia and/or paresis was statistically significant with retroperitoneal approach, the extension of aortic coverage, and blood loss greater than 1 liter. With our review of the initial 201 patients, female gender had a tendency toward increased risk of paraplegia possibly because they were more likely to receive a retroperitoneal approach and have a significant portion of the descending aorta covered. There was no correlation between female gender and incidence of paraplegia with our most recent review. We do not fully understand the exact link between the occurrence of paraplegia and retroperitoneal approach. We can theorize that the approach predisposes patients to increased risk of paraplegia because collaterals may be sacrificed if ligation of the hypogastric artery occurs. The increased coverage of the descending thoracic aorta, needed to manage a particular pathology, also increased the incidence of paraplegia due to the resultant coverage of the descending thoracic aorta leading to sacrifice of more intercostals and spinal arteries.

Covering of the left subclavian artery and previous abdominal aortic surgery did not prove to be associated with increased incidence of paraplegia or paresis, however, a larger sample size of these two subgroups is necessary to accurately evaluate these factors. Baril et al identified an increased risk of spinal cord ischemia in those patients that had previous or concomitant abdominal aortic repair. In

Table VI. Thoracic pathologies, neurocomplications, endoleak incidence, and 30-day mortality

	N (%)	*Early % endoleak*	*Late % endoleak*	*CVA*	*Paraplegia*	*Paresis*	*Mortality*
TAA	157 (48.5)	19 (12.0)	9 (5.7)	3 (1.9)	3 (1.9)	2 (1.2)	11 (7.0)
DTB	82 (25.3)	4 (4.8)	3 (3.6)	4 (4.8)	1 (1.2)	1 (1.2)	3 (3.6)
PU	34 (10.5)	1 (2.9)	0	0	1 (2.9)	0	1 (2.9)
PSA	26 (8.0)	0	1 (3.8)	0	0	0	1 (3.8)
MVAT	11 (3.4)	0	0	0	0	0	0
AoBF	9 (2.8)	0	0	0	0	0	0
Emboli	4 (1.2)	0	0	0	0	0	1
AoEF	1 (0.3)	0	0	0	0	0	1
Total	324(100)	24 (7.4)	13 (4.0)	7 (2.1)	5 (1.5)	3 (0.9)	18 (5.5)

TAA, Thoracic aortic aneurysm; *DTB,* dissection type B; *PU,* penetrating ulcer; *PSA,* pseudoaneurysm; *MVAT,* motor-vehicle accident transaction; *AoBF,* aorto-bronchial fistula; *Emboli,* embolization; *AoEF,* aortoesophageal fistula, *CVA,* cerebrovascular accident.

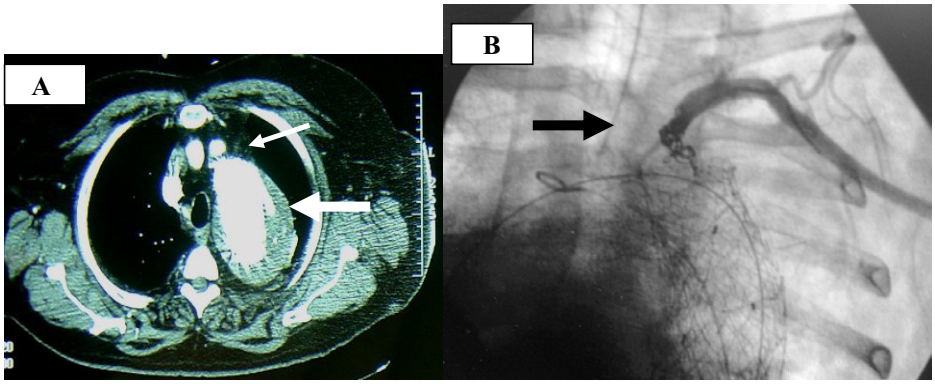

Fig 1. Coil embolization of left subclavian artery. **A**, Endoleak (large white arrow) on CT-scan originated from left subclavian artery (small arrow) as ultimately demonstrated by angiography. **B**, Coil embolization of the origin of the subclavian artery (arrow) to correct a type II endoleak.

Table VII. Endoleak occurrencey

	Type I	*Type II*	*Type III*	*Total*	*Endoleak elective cases*	*Endoleak Nonelective cases*	*P
Early endoleak	18 (5.5%)	4 (1.2%)	2 (0.6%)	24 (7.4%)	5.6%	6.0%	ns
TAA	16 (67%)	2 (50%)	1 (50%)				ns
Late endoleak	8 (2.5%)	3 (0.9%)	2 (0.6%)	13 (4.0%)			ns

TAA, Thoracic aortic aneurysm; *ns,* not significant.
*$P < .05$ = significant.

their series, four of the 28 patients (14.3%) who underwent endovascular thoracic aortic repair with previous or concomitant abdominal aortic repair developed spinal cord ischemia, while only one of 97 patients (1.0%) among the remaining thoracic endograft population developed spinal cord ischemia.[30]

Of the studies reviewed, four of them noted the need to cover the left SCA, most followed by carotid-subclavian bypass. Most of these studies did not show a correlation between spinal cord ischemia and covering or ligation of the SCA. However, one study did caution that ligation of the left SCA.[31] Despite left SCA revascularization, one patient with thoracic aortic debranching developed SCI.

Following this study, we have noted two additional observations of patients who developed paraplegia or paresis postoperatively after receiving thoracic ELG. First, hypertension helped to improve or resolve the neurologic deficit. Most probably, increased systemic pressure improved spinal perfusion. It is our practice to maintain the patient's systolic blood pressure approximately 20 mm Hg above baseline, and/or a mean arterial pressure greater than 90 mm Hg during the initial 48 hours. Second, any patient who developed paraplegia, and those with paresis who was not responsive to medically induced hypertension, had a spinal drain placed. Weigang et al demonstrated that the use of intraoperative evoked potentials can served as a guidance to determine which patient may benefit from SC drainage and adjustment of vitals.[32] Since this series, four patients developed SCI, three paraplegia and one parapareis. Spinal drains were placed in each of them. Three of the

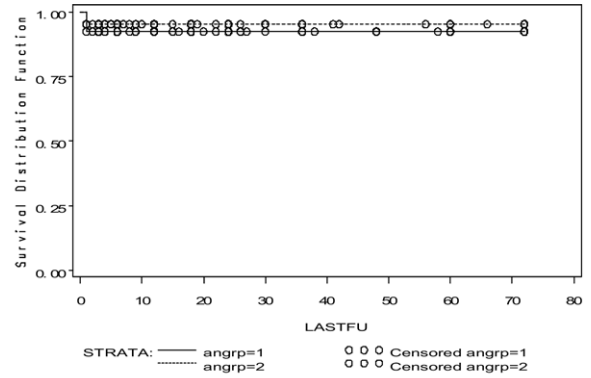

Fig 2. Actuarial survival: Related 30-day mortality for TAA vs other pathologies.

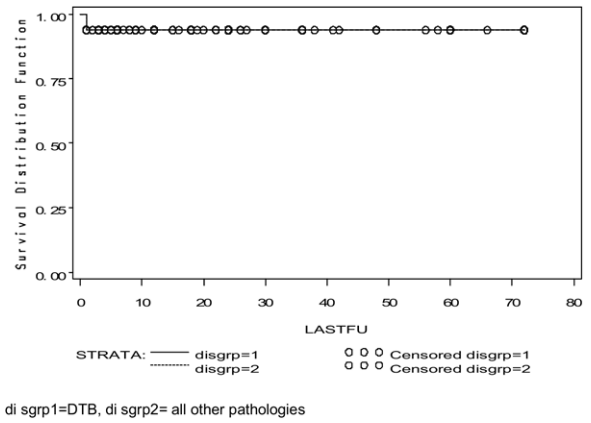

Fig 3. Actuarial survival: Related 30-day mortality for DTB vs other pathologies.

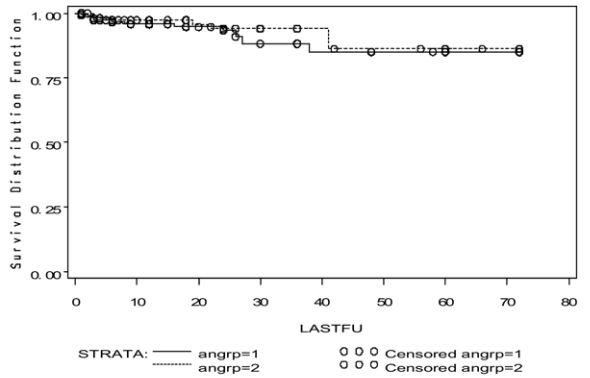

Fig 4. Actuarial survival: Unrelated >30-day mortality for TAA vs other pathologies.

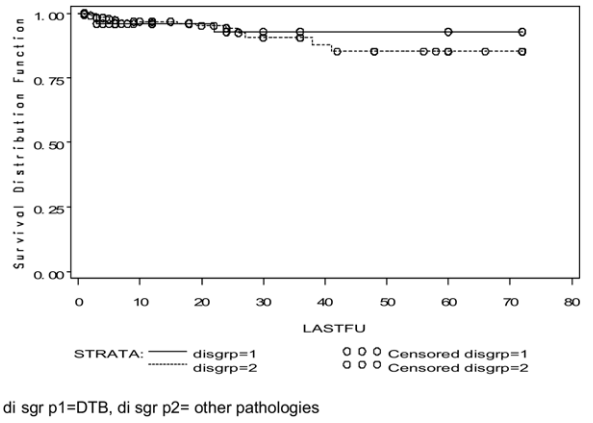

Fig 5. Actuarial survival: Unrelated >30-day mortality for DTB vs other pathologies.

four resolved completely, and one paraplegic patient resolved one lower extremity deficit and significantly improved in the other. Of these four patients with SCI, three were female, three had postoperative hypotension, and none had retroperitoneal approach. Those with more immediate drain placement had the best response. Neurologic deficits improved or resolved in patients who received spinal drainage within 6 hours of development of symptoms. Since this series, four spinal drains have been placed prophylactically, two in patients with previous AAA repair and the others in those with expectant extensive coverage of the descending thoracic aorta. Prophylactic spinal drains are placed in those we consider high risk for paraplegia. This includes those who will require extensive aortic coverage or retroperitoneal approach, particularly those of female gender. Although it has not been true in our current series, our initial data showed a correlation between female gender and increased incidence of SCI. Some members of our group have placed drains in patients with prior abdominal aortic repair, however, our data has not shown this cohort to be at increased risk for paraplegia.

Emergent treatment of thoracic aortic pathologies with endografts proved to be beneficial. Nearly a third of the cases (31.5%) were nonelective. There was no statistically significant incidence of complications including paraplegia and paralysis with these cases ($P = .170$) (Table V); nor was mortality increased. The occurrence of endoleak also did not increase with these cases. There were overall 18 (5.5%) periprocedural type 1 endoleaks and eight (2.5%) late type 1 endoleaks. Urgency of the procedure was not a predictive factor for increased risk of endoleak ($P = .186$). ANOVA analysis did prove that the type of pathology, that being TAA, had increased incidence of all endoleak types, type I, II, and III ($P = .049$). In reviewing this data, endoluminal grafting is a feasible alternative to open repair for nonelective treatment of thoracic aortic injuries and high surgical risk patients.[33-36] This subgroup of patients benefits the most since open repair in emergent situations carries high mortality, reported as high as 17% with a paraplegia incidence of 14%.[34]

Also, the regression of the aneurismal sac is notable. Preoperatively, the average sac size was 6.3 cm. Postoper-

atively, the average sac size decreased to 5.4 cm. Sac shrinkage occurred in 65% (102 of 107) of TAAs. This decrease in sac size was statistically significant ($P = .0001$). This finding is encouraging. In our experience, the use of an endograft to treat thoracic aortic pathologies with aneurismal disease resulted in decreased sac size and in some cases complete resolution of the sac. Perhaps, changes in thoracic pressure during the respiratory cycles play an important role that warrants attention in future studies.

Endografts were used in acute dissections often associated with malperfusion or intractable pain and in chronic dissections with aneurismal dilatation. Although controversial, the use of endografts in dissection seems to offer a new approach for this unique pathology. We believe patients with this condition can truly benefit from endovascular treatment, often preventing the progression of the dissection and its associated complications, such as aneurismal dilatation. Prevention of further dilatation and reduction in the false lumen was evident with endografting. In our early review of this pathology in 2005, there was a 20% reduction of aneurismal segments in acute dissection cases.[37] Others agree that the coverage of the entry tear with the ELG results in decreased diameter of the dissected aorta with either partial or complete thrombosis of the false lumen.[38] Nienaber et al showed stent-induced aortic remodeling for even uncomplicated acute type B aortic dissections.[39]

Management of symptomatic penetrating aortic ulcers with ELG is a less invasive and effective treatment. Our experience in treating this pathology in 34 (10.5%) patients revealed a 30-day mortality and endoleak incidence of 0%.[40] Similar encouraging outcomes have been reported with other aortic pathologies as such MVAT,[24,25,41,42] and AoBF[22] (Fig 6).

CONCLUSIONS

Endoluminal grafting is evolving as a primary treatment in thoracic pathologies including aneurysms, penetrating ulcers, pseudoaneurysms, and aortic transections. Patients with thoracic aneurysms can benefit from endoluminal grafting, however, anatomy and graft sizing is paramount in case selection. Limiting the coverage of the descending aorta may decrease spinal cord ischemia. Although not yet approved, diverse aortic pathologies can also be safely treated with ELG with a low incidence of morbidity. Paraplegia remains significantly low as a complication and increases in incidence with retroperitoneal approach, increased perioperative blood loss, and increased aortic coverage.

AUTHOR CONTRIBUTIONS

Conception and design: JR, DO
Analysis and interpretation: JR, DO, AS, ED
Data collection: DO, AS, LL
Writing the article: JR, DO
Critical revision of the article: JR, DO, LL, GW, JA, VR, ED
Final approval of the article: JR, DO, AS, LL, GW, JA, VR, ED
Statistical analysis: JR, DO

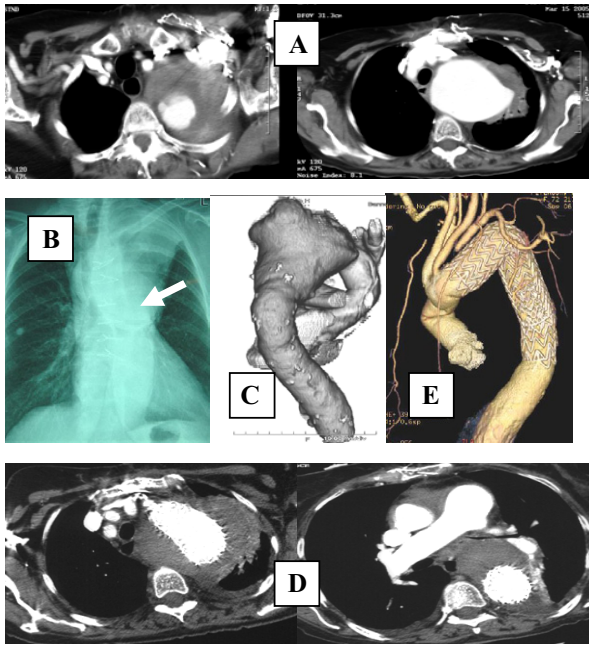

Fig 6. Images of a female patient presented with three episodes of hemoptysis and the bronchoscopic finding of a left aorto-bronchial fistulae. Three months earlier underwent an ascending aortic repair (TAA) with an interposition graft. **A**, Preoperative CT-scan view of an aneurysm of the proximal 3rd of the DTA causing an AoBF. **B,** CXR demonstrating a compression of the left main bronchus (white arrow). **C,** Preop 3-D CT reconstruction and the proximal aneurismal mass. **D,** Postoperative CT-scan views confirming the adequate exclusion of the aneurysm. The arrow highlights the proximity of the aneurysm to the bronchus. **E,** 3-D CT reconstruction 18 months after the treatment. The mass virtually resolved.

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