A Comparison of Open and Endovascular Descending Thoracic Aortic Repair in Patients Older Than 75 Years of Age

Himanshu J. Patel, MD, David M. Williams, MD, Gilbert R. Upchurch, Jr, MD, Narasimham L. Dasika, MD, Mary C. Passow, RN, Richard L. Prager, MD, and G. Michael Deeb, MD

Departments of Surgery and Radiology, Section of Interventional Radiology, University of Michigan Hospitals, Ann Arbor, Michigan

Background. Thoracic aortic endovascular repair (TEVAR) holds great promise in the elderly population. We conducted a concurrent comparison of TEVAR with open descending thoracic aneurysm repair (DTAR) in elderly patients to determine the more appropriate therapeutic option.

Methods. Since 1993, 93 patients aged 75 years and older have undergone open (n = 41) or endovascular (n = 52) descending aortic repair. Intervention indications included aneurysms, dissection, or traumatic injury. Mean maximum aortic diameter was 6.1 cm. Contained rupture was more frequent in TEVAR ($p = 0.005$); 52 needed arch repair, and 46 needed total descending repair.

Results. The mean age was 78.9 years (TEVAR, 80.6 vs DTAR, 76.9; $p < 0.0001$). The TEVAR patients had more significant comorbidities; 42 (80.8%) were prospectively identified as nonoperative candidates. Thirty-day mortality was higher in DTAR at 7 (17.1%) vs TEVAR at 3 (5.7%, $p = 0.1$). The composite end point of 30-day death, stroke, permanent paralysis, or dialysis requirement was similar (TEVAR, 9; DTAR, 10; $p = 0.45$). Median postoperative length of stay was shorter in TEVAR (6 days) vs DTAR (13 days; $p = 0.003$). Endoleaks were observed in 12. Actuarial survival at 48 months was similar (mean survival: TEVAR, 30.2 months vs DTAR, 33.7 months; $p = 0.49$).

Conclusions. Despite more complex preoperative comorbidities, the TEVAR group had shorter hospitalization, a trend towards a reduction in early mortality, and similar late outcomes. This comparative analysis suggests that thoracic endovascular repair may be a more suitable therapeutic option in this complex elderly group.

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Open repair for descending thoracic aortic pathology (DTAR) is a durable therapeutic option [1, 2]. Despite the excellent long-term results reported with DTAR, this approach carries a significant risk for early morbidity and mortality [1, 3–5]. Nowhere is this more readily apparent than in the elderly patient population. Previous studies have suggested that advanced age is a powerful independent predictor of early postoperative complications [1, 3].

It is in this setting that thoracic endovascular repair (TEVAR) potentially holds great promise. Numerous recent observational studies have demonstrated that TEVAR can be performed with acceptable early results, including in those patients deemed at high risk for traditional open repair [6–10]. Although the short-term benefits of TEVAR may reduce the significant morbidity encountered with DTAR, the long-term durability of endovascular therapy remains to be defined. In contrast with open repair, TEVAR has been associated with a significant need for reintervention on long-term follow-up [2, 6, 7, 11, 12]. Life expectancy in the elderly patient population is limited, however, suggesting that TEVAR may be a more appropriate therapeutic option. We conducted this study to specifically compare outcomes of open and endovascular descending aortic repair in patients aged older than 75 years to determine the more suitable approach.

Material and Methods

This study was approved by the Institutional Review Board (IRB) of the University of Michigan Hospitals (IRB #2003-0128) and informed consent requirements were waived.

Data from 93 patients aged 75 years and older who underwent operative therapy for descending thoracic aortic pathology at the University of Michigan Hospitals between 1993 and 2007 were prospectively collected and

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Address correspondence to Dr Patel, Section of Cardiac Surgery, CVC Room 5144, 1500 E Medical Center Dr, SPC 5864, Ann Arbor, MI 48109-5864; e-mail: hjpatel@med.umich.edu.

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retrospectively analyzed. The selection criteria for entry into this study were as follows:

- Indications for operation were identical in both groups and included (1) symptoms, (2) asymptomatic aneurysm 6 cm or larger or growing 1 cm per year or more, or (3) a saccular aneurysm of any size.
- The extent of pathology requiring repair was confined to the left thorax, that is, distal to the left carotid artery and proximal to the celiac artery.
- All patients were initially evaluated for open repair by a thoracic surgeon with specific expertise in thoracic aortic reconstruction. The option of TEVAR was only discussed with those patients (1) who were deemed a high-risk open-repair candidate (n = 42); (2) who had localized pathology (eg, saccular aneurysm or short segment fusiform aneurysm) in the mid-descending thoracic aorta suggesting extremely favorable anatomic characteristics for TEVAR (n = 7); or (3) who specifically requested to be evaluated for TEVAR (n = 3).

Final determination of anatomic suitability for TEVAR rested with a collaborative multidisciplinary team consisting of thoracic or vascular surgeons, or both, and interventional radiologists.

A patient who met any of the following anatomic criteria was excluded from TEVAR:

1. inadequate landing zone (< 2 cm in length), need to cover critical branch vessels, significant tortuosity, thrombus burden, or extensive calcification at the fixation sites;
2. presence of classic aortic dissection with a "double-barrel" lumen extending either from a previous type A dissection or extending beyond the thorax into the abdominal aorta (n = 8); or
3. lack of adequate access vessels to allow TEVAR.

The application of these criteria resulted in 41 patients undergoing DTAR and 52 patients undergoing TEVAR.

All procedures were done with general anesthesia. Endograft sizing for the TEVAR patients was performed using spiral computed tomography (CT) with or without three-dimensional reconstruction, or intravascular ultrasound (IVUS) or calibrated angiography, or both. Percutaneous access was used to obtain necessary angiograms; the access vessel for endograft delivery was isolated by using an open exposure. Device positioning and deployment were guided by angiographic landmarks or IVUS, or both.

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Table 1. Demographics, Comorbidities and Procedural Details With Univariate Analysis of the Study Cohort

Characteristics	Open Repair	TEVAR	*p* Value
Patient, total	41	52	
Demographics			
Age, mean ± SD years	76.8 ± 1.8	80.6 ± 4.0	<0.001
Male sex, No. (%)	29 (70.7)	26 (50)	0.06
Max aortic dimension, mean ± SD cm	6.5 ± 1.3	5.8 ± 1.8	0.05
Comorbidities, No. (%)			
CAD, No. (%)	18 (43.9)	29 (55.8)	0.3
CHF history, No. (%)	2 (4.9)	4 (7.7)	0.69
COPD, No. (%)	8 (19.5)	21 (40.4)	0.04
Diabetes, No. (%)	2 (4.9)	7 (13.5)	0.29
Hypertension, No. (%)	33 (80.5)	41 (78.9)	1.0
Pre-op creatinine, mean ± SD mg/dL	1.1 ± 0.2	1.2 ± 0.4	0.11
Prior AAA repair, No. (%)	3 (7.3)	14 (26.9)	0.03
PVOD, No. (%)	11 (26.9)	17 (32.7)	0.65
Tobacco use, No. (%)	26 (63.4)	33 (63.5)	1.0
Indication for intervention, No. (%)			
Fusiform aneurysm	19 (46.3)	24 (46.2)	1.0
Aortic dissection	9 (21.9)	7 (13.5)	0.41
Saccular/pseudoaneurysm	11 (26.9)	13 (25)	1.0
Traumatic aortic injury	2 (4.9)	2 (3.8)	1.0
ABF, mycotic aneurysm	0 (0)	6 (11.5)	0.03
Treated aortic segments			
Arch aorta	31 (75.6)	21 (40.4)	0.001
Total descending aorta	19 (46.3)	27 (51.9)	0.68
Procedural details			
Elective status	27 (65.9)	32 (61.5)	0.51
Aortic Rupture	2 (4.9)	14 (26.9)	0.005

AAA = abdominal aortic aneurysm; ABF = aortobronchial fistula; CAD = coronary artery disease; PVOD = peripheral vascular occlusive disease; TEVAR = thoracic endovascular aneurysm repair.

or type III endoleaks were treated when identified by either repeat balloon dilatation to profile or with additional coverage of the treated or adjacent aortic segments. Technical success of TEVAR was considered the placement of patent endoprosthesis and exclusion of the target aortic pathology without evidence of type I or III endoleaks.

All open thoracic aortic repairs were performed with extracorporeal perfusion support (mean perfusion times, 185.0 ± 81.0 minutes). Left heart cardiopulmonary bypass at normothermia was used in 12 patients. The remaining 29 patients had adjunctive use of deep hypothermic circulatory arrest (HCA) for a mean duration of 31.8 ± 9.6 minutes, as previously described [5]. Indications for HCA included aortic pathology that precluded use of aortic cross clamp (ie, presence of dissection, extensive thrombus or calcification at potential clamp sites) or the need to extend the resection into either the arch aorta or the entire descending thoracic aorta. In these operative procedures, HCA was instituted at a core body temperature of 18°C.

Postoperative management for prevention of spinal cord ischemia for both open and endovascular repairs was conducted according to standardized protocols, as previously described [5, 6]. Generally, lumbar drainage was used in both groups of patients for similar indications and included those patients who needed repair beyond the proximal third of the descending aorta or in the distal half of the descending aorta. Those patients with previous infrarenal aortic repair who underwent TEVAR also preferentially had placement of lumbar drains.

The primary outcome of this study was all-cause mortality. Data were collected from clinic visit notes, hospital charts, imaging studies, and death was verified by interrogation of the National Death Index. Follow-up was 100% complete as of August 2007 (mean, 33.1 ± 36.9 months).

Statistical Analysis

Data were analyzed using SPSS software (SPSS Inc, Chicago IL). Dichotomous variables were evaluated using χ^2 analysis and continuous variables by using one-way analysis of variance. Survival was analyzed by Kaplan-Meier methods. All results with $p < 0.05$ were considered statistically significant.

Results

The mean age of the entire cohort was 78.9 ± 3.8 years, and 40.9% were men. Demographics and comorbidities for the two groups are listed in Table 1. Essentially, the TEVAR group was older, and had smaller thoracic aneurysms and a higher frequency of COPD or prior infrarenal abdominal aneurysm repair. Indications for intervention, extent of repair, and procedural details are also listed in Table 1. The procedure was considered elective in 59 patients (63%); however, contained rupture was more frequently seen in the TEVAR group ($p = 0.005$).

Technical success in TEVAR was achieved in 50 pa-

Table 2. Cause of In-Hospital or 30-Day Mortality

Patient Group	Thoracic Aortic Pathology	Extent of Repair	Day of Death	Cause of Death
DTAR				
HCA use				
No	Pseudoaneurysm	Mid-descending	25	Paraplegia, respiratory failure[a]
Yes	Saccular Aneurysm	Distal arch, proximal descending	0	Intraoperative protamine reaction, intraoperative hemorrhage
Yes	Acute type B dissection with rupture	Distal arch, proximal descending	0	Intraoperative cardiac ischemia preventing separation from bypass
Yes	Fusiform aneurysm	Distal arch, total descending	3	Dense stroke[a]
Yes	Saccular aneurysm	Distal arch, proximal descending	4	Dense stroke[a]
Yes	Fusiform aneurysm	Total descending	34	Distal embolization, renal and mesenteric ischemia[a]
Yes	Saccular aneurysm	Distal arch, total descending	0	Intraoperative hemorrhage from proximal aortic suture line disruption
TEVAR				
	Acute type B dissection	Distal 2/3 descending	11	Ruptured infrarenal AAA
	Penetrating ulcer/intramural hematoma	Distal arch, proximal descending	0	Ruptured thoracic aorta
	Saccular aneurysm	Mid 2/3 descending	2	Ruptured infrarenal AAA

[a] Care withdrawn.

AAA = abdominal aortic aneurysm; DTAR = open descending thoracic aortic repair; HCA = hypothermic circulatory arrest; TEVAR = thoracic endovascular aneurysm repair.

tients (96.2%). Devices used included Gore TAG (W. L. Gore & Associates, Flagstaff, AZ) in 30, Talent (Medtronic Inc, Minneapolis, MN) in 15, custom fabricated in 5, and TX2 (Cook Inc, Bloomington, IN) and AneuRx (Medtronic) aortic cuff devices in 1 patient each. Device delivery was through a transfemoral approach in 43 patients and an iliac approach using a conduit in 9.

To achieve sufficient proximal landing zones, subclavian arterial coverage was needed in 15 patients; 10 had undergone either prior or concomitant left carotid–left subclavian arterial bypass. In 4 patients the aortic coverage extended into the visceral segment aorta to achieve adequate distal seal zones. One patient had celiac stent placement because of partial celiac arterial coverage at the time of TEVAR. Another patient had intentional coverage of a highly stenotic celiac artery without revascularization. Visceral bypass performed in the remaining 2 patients. In one of these, an ileo–hepatic artery bypass was performed at the time of repair of a ruptured infrarenal aneurysm, and an elective TEVAR was subsequently done for a large saccular distal descending aneurysm. The other patient required coverage of both superior mesenteric and celiac arterial origins (< 1 cm apart) to treat a ruptured distal descending thoracic aortic saccular aneurysm. Because he required common iliac arterial conduit access for TEVAR, the ileo–superior mesenteric bypass was performed concomitantly.

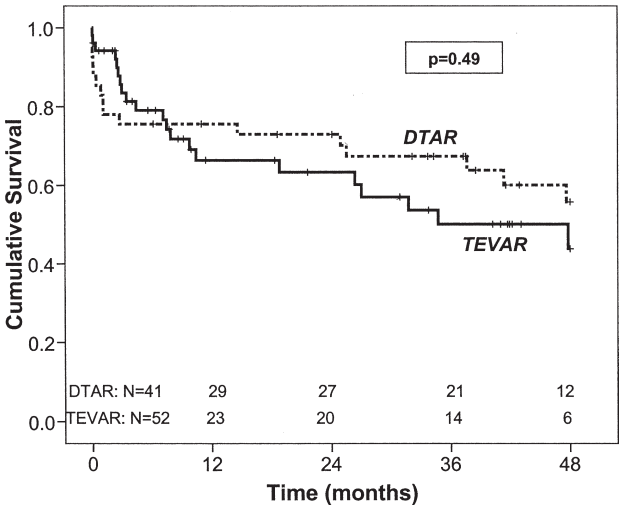

Fig 1. A Kaplan-Meier survival analysis comparing open descending thoracic aortic repair (DTAR) with thoracic aortic endovascular repair (TEVAR) demonstrates that after either open (dashed line) or endovascular thoracic aortic repair (solid line), there is no significant difference in survival for patients aged older than 75 years. Mean ± standard deviation survival was 30.2 ± 3.0 months for TEVAR vs 33.7 ± 3.2 months for DTAR (p = 0.49).

Early Results

There was a trend towards a reduction in early mortality (defined as either in-hospital or within 30 days) in the TEVAR group at 3 (5.8%) vs DTAR with 7 (17.1%, $p = 0.1$). The causes of early mortality are listed in Table 2. No preoperative variables correlated with this outcome. Of note however, of the 3 TEVAR patients who died early, two deaths were caused by rupture of infrarenal abdominal aortic aneurysms within the early postoperative period. These patients included one who had a synchronous 6.3 cm-saccular thoracic aneurysm with a 5.6-cm infrarenal abdominal aortic aneurysm, and another who had a localized mid-descending thoracic aortic dissection with a 5-cm aneurysm and a separate infrarenal 9-cm abdominal aortic aneurysm. These patients died on postoperative days 2 and 4, respectively. Because their intraoperative imaging was unremarkable, it is unlikely that technical issues with device delivery were responsible for the observed mortality. The remaining patient, who had short segment distal arch coverage for a penetrating ulcer with intramural hematoma, died the night of the procedure of a ruptured descending thoracic aorta.

The incidence of stroke was also similar, occurring in 6 DTAR patients (14.6%) vs 5 TEVAR patients (9.6%; $p = 0.53$). Again, no preoperative or intraoperative variables correlated with the occurrence of postoperative stroke. For the open repair group, the incidence of stroke was not statistically related to the use of HCA (n = 5) vs left heart bypass (n = 1; $p = 0.65$). Permanent lower extremity paralysis or paresis was seen in 3 patients (3.2%), including 2 who underwent DTAR. The third patient, who was from the TEVAR group, emerged from anesthesia neurologically intact, and her lumbar drain was removed on the first postoperative day. This patient then manifested lower extremity paresis during the ensuing 12 hours, secondary to an epidural hematoma. Despite neurosurgical intervention, this patient had significant lower extremity paresis and was unable to resume ambulation.

Renal failure needing dialysis occurred in two patients (2.1%), one in each group ($p = 1.0$). An attempt to increase the event rate by generating a composite outcome of early mortality, stroke, permanent paralysis, or need for dialysis did not yield any univariate correlates.

Finally, the TEVAR group had a significantly shorter postoperative length of stay, at a median of 6 days vs 13 days for DTAR patients ($p = 0.003$).

Late Results

The overall crude mortality rate for the entire cohort at last follow-up was 45.2% and did not differ between groups (DTAR, 19 vs TEVAR, 23; $p = 1.0$). A Kaplan-Meier analysis (Fig 1) demonstrated that although there was a significant force of mortality in this elderly cohort, intermediate-term survival was similar ($p = 0.49$).

No patients in the DTAR group required further therapy for the treated or adjacent aortic segments, including anastomotic pseudoaneurysms, infected grafts, or fistulae from grafts to adjacent organs. In contrast, endoleaks were seen in 12 patients (23.1%) from the TEVAR group. Five patients had indications for conversion to open repair but were considered nonoperative candidates and had no further therapy. The details regarding all patients with new or persistent endoleaks are reported in Table 3. Of note, all four proximal endoleaks were related to poor

Table 3. Details Regarding New or Persistent Endoleaks

Patient	Aortic Pathology	Endograft Used	Treated Aortic Segments	Endoleak Type[a]	Outcome
1	Fusiform aneurysm	Gore TAG	Total descending aorta	Early type II	No imaging follow-up, died at 47.8 months
2	Fusiform aneurysm	Gore TAG	Total descending aorta	Early distal type I	Non-op candidate, increase in aneurysm size; died at 2.5 months
3	Saccular aneurysm	Medtronic Talent	Total descending aorta	Either early type I or II	No imaging follow-up, died at 4.4 months
4	Saccular aneurysm	Gore TAG	Arch aorta	Early proximal Type I	Non-op candidate; required prox extension, but had persistent endoleak at region of high curvature; likely died from ruptured aorta at 34.7 months
5	Penetrating ulcer/ Intramural hematoma with contained rupture	Medtronic Talent	Distal 2/3 descending thoracic aorta	Late (1.5 years) type III	Non-op candidate, required repeat TEVAR, alive at 41.7 months
6	Chronic dissection	Gore TAG	Proximal 2/3 descending aorta	Early proximal type I or II	Non-op candidate, refused further intervention, endoleak present at 21.6 months
7	Acute dissection with aneurysm	Gore TAG	Distal arch, proximal 2/3 descending aorta	Early proximal type I and II	Non-op candidate, repeat TEVAR with subclavian artery coiling at 1 month to extend landing zone into region of high curvature, persistent type II with smaller sac size
8	Fusiform aneurysm	Gore TAG	Total descending aorta	Early type II	Observation, stable sac at 8.6 months
9	Fusiform aneurysm	Gore TAG	Mid 2/3 descending aorta	Early type II	Observation, stable sac at 5.6 months
10	Saccular aneurysm	Gore TAG	Distal arch, total descending aorta	Early type II	Observation, stable sac size, died at 2.8 months
11	Saccular aneurysm with contained rupture	Gore TAG	Distal arch, total descending aorta	Early type II vs. III	Non-op candidate, refused further therapy, stable sac size at 4 months
12	Penetrating ulcer/ Intramural hematoma with contained rupture	Gore TAG	Distal arch, proximal 1/3 descending aorta	Early proximal type I along left subclavian artery	Nonoperative candidate, coiled left subclavian artery, persistent though smaller endoleak; died at 2.6 months

[a] Endoleaks are classified as early if occurring within 30 days of the primary procedure and late if occurring thereafter.

seal on the inner curve of the arch and proximal descending thoracic aorta.

Comment

Descending thoracic aortic pathology is more frequently present in the elderly patient population. Associated comorbid conditions, decreased functional status, and overall conditioning in this group can limit the ability to provide a suitable therapeutic option to ameliorate the risks of rupture, dissection, or aneurysm-related death. The advent of thoracic endovascular repair (TEVAR) has potentially extended the range of patients considered suitable for aortic repair by providing a less invasive option, without the significant rates of morbidity and mortality typically associated with open descending aortic resection [1, 3–11]. Prior work from our group, as well as others, has suggested that this approach can be used with acceptable early and late results in those patients considered too high risk for the more conventional approach [6–11]. Although our previous work suggests an improvement in survival for TEVAR compared with

medical therapy for the high-risk cohort, the present study was undertaken to concurrently compare open and endovascular repair for the older patient population to determine the more suitable option [10].

Previous direct comparisons of TEVAR vs open repair have generally favored the endovascular approach [13–15]. The first reported direct comparison of the two treatment modalities used an historical open surgical group and suggested feasibility of TEVAR [13]. The United States Food and Drug Administration (FDA)–sponsored trial for the Gore device showed a decrease in risk for paraplegia, stroke, renal failure, and death for the group undergoing endovascular repair. In that study, however, the open surgical group was enrolled both in a concurrent and retrospective manner. In addition, the rates of neurologic complications, particularly that of paraplegia, were higher than those reported in other series of open repair, including ours [1, 3–5, 14]. In another direct comparison, Stone and colleagues [15] suggested a trend toward a difference in early mortality favoring TEVAR. Although their comparison was concurrent, their reported rates of major morbidity and mortality with open surgery were also significantly higher than described in other studies, including ours [1, 3–5].

These studies have suggested early advantages for TEVAR; however, the long-term results with TEVAR are uncertain [6–12]. Endoleak rates of 5% to 30% have been reported, and certain types have been associated with the risk for aneurysm-related death [6–12]. This limitation of TEVAR is of particular concern when younger patients are evaluated for intervention. In that age group, the risk of open repair in experienced centers is relatively low, and the long-term results of DTAR are excellent [1–5]. In contrast, the elderly patient presenting with thoracic aortic disease may not have a prolonged life expectancy because of associated comorbid conditions and therefore may not derive benefit from the durability of DTAR.

With these considerations, we performed this study to answer whether TEVAR was a better option in elderly patients. Our findings indicate that TEVAR has significant early benefit, including a trend towards a lower early mortality as well as a reduced length of hospitalization. Despite the incidence of endoleak seen in our study, our late results suggest that mid-term survival is not different after TEVAR compared with after open repair. Several additional observations from this study support our conclusions regarding the more suitable therapy in this group:

1. These results were demonstrated in a TEVAR group, which was older by a mean age difference of 4 years.
2. The pathologic indications for intervention in the TEVAR group were typically a more complicated type, including a higher proportion of patients with contained rupture or high-risk pathology, such as fistulous connections or mycotic aneurysms.
3. Most of the TEVAR patients were prospectively identified as high-risk or "nonoperative" candidates. Five of 12 patients (41.7%) in whom endoleaks developed, with indications for conversion to open repair, were not offered DTAR for this reason. In fact, in the 4 patients with proximal endoleaks, these developed at the inner arch curvature.

With continued refinements in endograft technology, particularly with the highly flexible or precurved proximal configurations to better fit the arch anatomy, it is possible that these late results will only continue to improve and may tip the balance in favor of the endovascular procedure.

This study has some important limitations, which are primarily related to its retrospective nature. This report encompasses the entire 15-year TEVAR era at the University of Michigan and thus describes an evolving experience with its limitations and benefits. Until the recent FDA approval, TEVAR was only available at our institution for "inoperable" patients on a compassionate-use basis or as part of clinical trials, including the high-risk arm of the Medtronic Talent trial. Information about anatomic suitability for TEVAR for all open operative repair patients is incomplete, and criteria for TEVAR suitability changed with our increasing experience as well as with the introduction of commercially available endografts.

Most important, as a result of these limitations, there is a selection bias in this study for entry into the two groups. This bias, which preferentially shunted "inoperable" patients to the TEVAR arm, likely led to the observed increased age and more complex comorbidities identified in this group. These differences in the two patient groups, however, only serve to strengthen the conclusions.

Although the TEVAR group was older and sicker than the DTAR group, the endovascularly treated arm had either improved or equivalent outcomes. Future studies to confirm these results could include a multicenter randomized trial similar to those seen with Endovascular Aneurysm Repair-1 (EVAR-1) and Dutch Randomised Endovascular Aneurysm Management (DREAM) trials for evaluation of abdominal endovascular repair [11].

Our current algorithm when evaluating patients with descending thoracic aortic pathology involves determining suitability for open repair (ie, determine comorbidities) as well as for TEVAR (ie, comorbidities, but also anatomic constraints). If patients are younger or have few comorbidities, or both, they are offered DTAR as a first choice. In contrast, for those patients with advanced comorbid conditions or those who are older, or both, TEVAR is offered as a first choice. Finally, a number of patients do not currently meet TEVAR criteria because of anatomic constraints owing to inadequate landing zones, chronic thoracoabdominal dissection, or inadequate access vessels, and they are offered open repair, if appropriate.

In summary, this comparison of both open and endovascular thoracic aortic repair suggests that even in a complex elderly population, TEVAR emerges as the therapeutic option of choice to reduce early mortality,

shorten hospital stay, and deliver similar late results compared with open repair.

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DISCUSSION

DR JOHN S. IKONOMIDIS (Charleston, SC): I would like to congratulate you on an excellent presentation of a series of very difficult patients with a lot of comorbidities. The first thing I would like to ask you about is the endoleak rate of 23%. While this is within the bounds of sort of published series, it still is high, and my question to you is, what things have you learned from these late endoleaks that you perhaps have implemented into your practice or allowed you to change your practice to avoid these in the future?

DR PATEL: In our study, 12 of the 52 TEVAR patients had endoleak. Of these, 4 had proximal endoleaks related to poor seal on the inner curve of the arch. I suspect that this will only improve with evolving thoracic endograft technology including precurved endografts. Another option, if feasible, is to consider debranching procedures, such that the landing zone is in a straighter portion of the aorta. For some reason, in this study, we also had a larger number of patients with a type II endoleak from intercostal or bronchial arteries, which we observed for a stable sac dimension. I am not sure what can be done preoperatively to eliminate these type II endoleaks. Of course, if a patient presents with either a proximal landing zone endoleak, or has a persistent type II endoleak with an increasing sac size, conversion to open repair is indicated. In the current study, however, 5 of the 12 patients with endoleak had indications for conversion to open surgery but were considered nonoperative candidates. Because of their high-risk status, they are either being observed or have succumbed to either their aneurysm disease or their comorbidities.

DR IKONOMIDIS: My next question has to do with the disparity in aneurysm size between the open and the endovascular groups. Now, I acknowledge that there is some difference in your patient population, but the trend was toward offering stent grafting to patients with smaller aneurysms, and I was wondering if you would comment on your stance with regards to offering stent grafting in general to patients with somewhat clinically smaller aneurysms that might not be suitable for open repair. I would also like to direct this question to the panel.

DR PATEL: Our indications for intervention at the University of Michigan are the accepted indications for intervention with either open or endovascular approaches, namely a size of more than 6 cm, a growth rate of more than 1 cm a year, or a saccular aneurysm. We have really not yet fully embraced the notion of treating smaller thoracic aneurysms, because there is still a risk for paraplegia, an underreported risk for stroke with endovascular repair, and, as well, a risk for early mortality with this approach. With the understanding that smaller (ie, 5 cm) aneurysms still have a risk for complications as well as the fact that the clinical decision making requires an analysis of intervention risk to survival benefit, we look forward to a future randomized trial to guide our therapeutic approach.

DR JOHN A. KERN (Charlottesville, VA): I would like to ask the panel, what about those not high-risk patients but those very acceptable-risk patients with stellar anatomy for an endograft. Should we be treating their aneurysms at smaller sizes?

DR TOMAS D. MARTIN (Gainesville, FL): I would probably equate those of us who do a moderate number of endografts, and I will include our program in that, we have over 300 thoracic endografts now, I would equate that to the cardiologists when stents first came around. When single-vessel disease was treated medically and when stents came around, because they could, they did, and I have seen in our practice treating smaller aneurysms because they have good anatomy.

I don't know the answer to the question, but I see us falling

into that same pattern, and it is because we have gotten excellent results. And, yes, there are problems. We have seen paraplegias, and our incidence is about 3% to 4%, our stroke rate is about 3%. They do have potential problems.

So the answer to your question, I don't know how to answer, but I think that we are treating; whether we should or we shouldn't, I think we are.

DR NICHOLAS T. KOUCHOUKOS (St. Louis, MO): I would second that. I would like to ask a question about your study groups. How many of the patients who were treated with open operation were not candidates for an endografting procedure? We are in an apples and oranges situation here, because these groups are not really entirely comparable. If you matched the patients who were suitable for TEVAR and matched them with the patients who had an open operation, what would the outcomes be?

DR PATEL: That is a great question. I don't have the answer to that. I don't know what percentage of open repair patients were anatomically not suitable for an endovascular approach. I will tell you that the prevalence of arch resection was higher in the open repair group. We also acknowledge that this study, while it is concurrent and comparative, has two somewhat different groups. The TEVAR group is older and sicker, and patients in this group were often considered unsuitable for open operative repair. The outcomes however show either an improvement or equivalence with endovascular therapy. The differences between the groups therefore only serve to strengthen our conclusion that TEVAR should be the therapeutic option of choice in the elderly patient population.

DR MARC MOON (St. Louis, MO): I think it will be important, though, for you to go back and look at those patients and find out which one of them were and were not appropriate for stent grafts, because then you could actually compare the groups.

DR ANTHONY L. ESTRERA (Houston, TX): I have two quick questions. Regarding your open repairs, how many were performed via left chest using circulatory arrest. Our experience using left chest circulatory arrest has not been good, and if I remember correctly, the Michigan group does a lot of left chest circulatory arrest for descending thoracic repairs.

The second question is related to your follow-up regarding the patients undergoing thoracic endograft repair. In reviewing the topic both for infrarenal and descending thoracic stenting, I have noticed that there is always a crossover in survival between open vs endovascular repairs, at about 2 years, and although yours crossed over at about 1 year, it was not significantly different. Thus, why are these patients with thoracic endovascular stents dying in the mid- and long-term?

DR PATEL: I didn't hear the very last part of it, but I will address the first question, and that is the issue of needing circulatory arrest. You are right, we presented our results with resection of descending aneurysms requiring circulatory arrest 2 years ago at the Southern Thoracic. Our indications for use of deep hypothermic circulatory arrest for descending thoracic aortic resection include either the presence of pathology precluding the use of a cross-clamp, or the need to extend the resection into the arch. Finally, based on some of the work that Dr Kouchoukos has previously presented with decreases in neurologic morbidity, we preferentially will use circulatory arrest for those patients that have needed total descending thoracic aortic resection. In this cohort of 41 patients who had open repair, 29 of them had the use of deep hypothermic circulatory arrest. The remaining underwent resection with left heart bypass. None were done just with a clamp and sew.

And I am sorry; I did not hear the very last part.

DR ESTRERA: The second question was related to the crossover with regards to long-term survival with the stent vs the open repair, and in reviewing all the other series, both infrarenal and descending, they seem to cross at 2 years. Why are the stent patients dying long term?

DR PATEL: Some of the late mortality is attributable to endoleak and inability to convert to the necessary open repair that we have already discussed with Dr Ikonomidis. We also have a few patients in whom we are uncertain of the etiology of death.