Emergency endovascular interventions for acute thoracic aortic rupture: Four-year follow-up

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Objective: High mortality and paraplegia rates associated with the surgical management of acute thoracic aortic ruptures limit its success. It was our objective to evaluate whether emergency endovascular interventions would improve the outcomes of these patients.

Methods: Sixty patients aged 28 to 83 years were admitted to our institution with an acute rupture of the thoracic aorta (27 ruptured aneurysms, 15 perforated type B dissections, 18 traumatic ruptures). Twenty-eight patients were treated surgically with cardiopulmonary bypass, and 32 patients were acutely treated with an endovascular stent graft. Medical records were reviewed for prehospital and emergency department data, operative findings, and outcomes. Patients were followed up at yearly intervals with high-resolution multidetector computed tomographic angiography.

Results: Perioperatively, there were 1 death (3.1%) among the 32 patients in the endovascular group and 5 deaths (17.8%) among the 28 patients in the surgical group. There were 4 late deaths in the endovascular group and 1 in the surgical group. There were 2 access failures in the endovascular group. There were 1 stroke in the endovascular group and 1 case of paraplegia in the surgical group. Three patients in the endovascular group had endovascular leaks develop that required reintervention. Two patients in the endovascular group had late thrombosis of the left subclavian artery.

Conclusion: Despite encouraging early outcomes, midterm results suggest a trend toward increased reintervention and late complication rates in the endovascular group. Therefore continued surveillance of patients treated with stent grafts is necessary.

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Advan-
 tages of endovascular treatment relative to conventional surgical management of acute thoracic aortic rupture include reduced perioperative mortality and morbidity rates. Emergency endovascular intervention may be of particular benefit for patients of advanced age with severe comorbidities. In our single-center experience, we reported superior early outcomes for less invasive endovascular approach relative to a concurrent control group treated by conventional open surgery.¹ However, intermediate- and long-term results of emergency endovascular interventions are scarce, and no comparative studies are reported in the literature. This study was primarily undertaken to assess the intermediate-term results of emergency repair of acute thoracic aortic ruptures and compare outcomes of the endovascular approach with those of conventional open surgical management.

TABLE 1. Preoperative demographic and clinical data

Characteristic	Endovascular (n = 32)	Open (n = 28)
Age (y, mean $\pm$ SD)	61.3 $\pm$ 17.1	68.7 $\pm$ 21.3
Male (No.)	17	18
Female (No.)	15	10
Previous thoracic surgery (No.)	3	5
Multiple traumatic injuries (No.)	3	4
Hypertension (No.)	14	10
Chronic obstructive pulmonary disease (No.)	9	2
Traumatic brain injury (No.)	1	0
Cardiac disease (No.)	7	2
Renal failure (No.)	2	1
Hepatic disease (No.)	2	1
Marfan disease (No.)	1	0
Ruptured thoracic aortic aneurysm (No.)	15	11
Perforated type B dissection (No.)	10	5
Traumatic rupture (No.)	7	12

Methods

In our practice, we define acute thoracic aortic rupture as follows: recent onset of thoracic pain, evidence of leakage from the aorta, periaortic hematoma, and left-sided hemothorax. Between November 1999 and May 2002, a total of 60 consecutive patients with acute rupture of the thoracic aorta were admitted to our institution. Thirty-two of these patients were acutely treated with an endovascular stent graft, and 28 patients were treated with conventional open surgical graft interposition under cardiopulmonary bypass. Overall, 27 ruptured descending thoracic aortic aneurysms, 15 perforated type B dissections, and 18 traumatic ruptures of the descending aorta were treated.

Patient Allocation and Group Comparability

Within the period mentioned, all patients with an acute rupture of the thoracic aorta were included in the study. Patients were allocated to either surgical or endovascular treatment in a nonrandomized fashion. Table 1 lists the preoperative demographic and clinical data of all patients. All admitted patients with acute lesions of the descending thoracic aorta were primarily considered as potential candidates for endovascular stent-graft placement. Lesions involving the aortic arch or originating from the ascending aorta, a heavy tortuous course of the thoracic aorta, and a diameter of the common iliac arteries of less than 7 mm excluded the patient from endovascular stent-graft deployment.

A prerequisite for stent-graft placement was landing zone diameter of less than 44 mm. This is because of a lack of commercially available stent grafts of larger sizes and the fact that we tend to oversize by 3 to 5 mm. Another prerequisite was landing zone length of 1.5 cm or greater to the celiac axis and the left common carotid artery, because in an emergency setting we would routinely sacrifice the left subclavian artery. Concomitant diseases, rendering patients high-risk surgical candidates, were chronic obstructive

pulmonary disease, recent stroke, cardiac disease, renal failure, and hepatic disease.

Preoperative Work-up

All patients included in this study underwent the same diagnostic and resuscitation protocol. On admission, high-resolution multidetector computed tomographic angiography from the thorax to the groins was used to determine the size and type of the aortic lesions (ie, dissection, aneurysm, transection), to assess the potential landing zones, to allow calculation of stent-graft sizes, and to assess the caliber of the access vessels. Stent grafts either were available off the shelf or were delivered within 4 hours on request.

Our resuscitation protocol was the same for both the surgical and the endovascular groups. Depending on clinical status at admission to the hospital, most patients required some form of immediate medical attention to stabilize their hemodynamic condition and allow the planning of an endovascular or surgical procedure. All patients were thus monitored in the intensive or intermediate care ward.

To proceed with an endovascular procedure, patients had to respond to our resuscitation therapy, fulfilling the following criteria: systolic blood pressure 90 to 120 mm Hg, heart rate less than 110 beats/min, central venous pressure 7 to 14 cm H₂O, and hemoglobin greater than 10 g/dL. Most patients presented in a state of shock and needed either inotropic resuscitation with dopamine or norepinephrine in moderate dosages or volume resuscitation with colloids and blood products. Overall, 27 patients needed opioids to treat acute back or chest pain. Five patients were severely hypertensive on admission, with systolic blood pressures as great as 200 mm Hg. To control this hypertension, β -blockers, α -blockers, and nitrates were used.

Stent-Graft Placement

Our technique of stent-graft placement has been described elsewhere. In short, two different commercially available thoracic stent-graft systems were implanted in this study, Talent LPS (Medtronic World Medical, Sunrise, Fla) and Excluder (W.L. Gore & Associates, Inc, Sunnyvale, Calif). After successful surgical exposure of the femoral artery and transverse arteriotomy, a pigtail catheter was positioned in the ascending thoracic aorta over a soft, angled guidewire (Radiofocus standard guidewire M; Terumo, Tokyo, Japan). The guidewire was exchanged to a super-stiff guidewire (Lunderquist extra stiff; Cook Inc, Bloomington, Ind) for stent-graft insertion. After an initial, angulated digital subtraction angiography of the thoracic aorta with 30 mL contrast material (Visipaque 320; Nycomed Amersham, Buchler, Germany) and a flow rate of 15 mL/s, 5000 IU heparin was administered intra-arterially. The stent-graft system was then advanced into the desired position, and correct location was verified by an additional digital subtraction angiography immediately before stent-graft deployment. To avoid downstream migration of the device during deployment, systolic arterial blood pressure was lowered to 70 mm Hg with sodium nitroprusside just before device release or short cardiac arrest was achieved by intravenous injection of adenosine (6-12 mg) to ease device deployment and allow exact device positioning at the orifice of the left subclavian or carotid artery. In all cases, postdilatation was performed with an endoballoon to obtain optimal shape and sealing of the implanted stent graft.

A final digital subtraction angiography was performed to verify appropriate stent-graft location and to demonstrate free perfusion of the supra-aortic vessels as well as the stent graft. All interventional materials were removed, and the arteriotomy was closed with a continuous 5.0 Prolene suture (Ethicon, Inc, Somerville, NJ). All patients were transferred to the intensive care unit for postoperative surveillance for at least 4 hours. All patients had a single-shot, broad-spectrum antibiotic prophylaxis (third-generation cephalosporins) just before the initial incision. Follow-up examinations were performed with multi-detector computed tomographic angiographic scans before discharge and at 3, 6, and 12 months after implantation.

Surgical Technique

After transfer to the operating room, double-lumen endotracheal intubation and routine hemodynamic monitoring were performed. For spinal cord protection, cerebral spinal fluid drainage was used in 20 patients (71.4%). Before establishment of femorofemoral bypass, all patients had systemic heparinization. Access to the descending thoracic aorta was gained through a left posterolateral thoracotomy incision, through the fifth intercostal space. The left lung was then collapsed, and the aorta proximal and distal to the diseased segment was dissected and isolated circumferentially. Profound hypothermia of 18°C was induced in all patients. The proximal anastomosis was performed between clamps. After transection of the aorta, the proximal anastomosis was made first with a collagen-impregnated Dacron polyester fabric tube graft. Small segmental intercostal arteries were oversewn, and large ones were reattached to the graft. Circulation to the lower extremities, kidneys, and viscera was provided by distal aortic perfusion. Just before completion of the distal anastomosis, the distal clamp was opened, arterial perfusion was reestablished through the femoral artery, and the graft was deaired. Rewarming was then initiated after adequate hemostasis, and femorofemoral bypass was discontinued. After successful weaning from bypass, the heparin was reversed with protamine sulfate.

Follow-up

Perioperative outcomes were evaluated by reviewing all medical records for prehospital and emergency department data, operative and interventional findings, and outcomes. After discharge, all patients treated with endovascular stent grafts were followed up in our hospital with high-resolution multidetector computed tomographic angiography at 6 months and at yearly intervals thereafter. Follow-up was complete for all patients. Follow-up for open surgery was obtained by contacting the respective general practitioners and patients or family members 1 year postoperatively and between October and December 2003. Follow-up was also complete for this group of patients. Postoperative complications and mortality were determined by acquiring autopsy reports or medical records and hospital discharge letters.

Results

The mean follow-up was 36.4 ± 12.8 months (maximum follow-up 50 months). The overall perioperative mortality was 10%. There was 1 early death in the endovascular group

Figure 1. Explanted Talent stent-graft prosthesis 33 months after being deployed.

(3.1%), that of a patient with a ruptured thoracic aortic aneurysm. Perioperative hemodynamic stabilization of this patient was not entirely possible, and although a steady state was achieved, the patient remained in tachycardia (heart rate 110 beats/min) and hypotensive (blood pressure 90/60 mm Hg). On induction of general anesthesia, the patient went into left ventricular failure and died before access for stent-graft placement was established.

In the surgical group, causes of early death were low-output syndrome in 2 patients, sepsis in 1, and intraoperative hypovolemia in 2. No further deaths occurred in either group within the first 12 postoperative months. There were 4 additional deaths in the endovascular group (15.6%) at 14, 36, 40, and 44 postoperative months. Three were stent-graft related (1 aneurysm, 1 dissection, and 1 traumatic transection). The landing zones were within 2 cm of undiseased aorta in the patients with aneurysm and traumatic transection and covering the intimal tear in the patients with dissection. In none of these patients was severe angulation of the aorta present. The cause of death was late aortic rupture in 2 cases, as confirmed by autopsy. One of these patients had angiographic evidence of a proximal endovascular leak at 36 postoperative months, as diagnosed at his local hospital. Only hours after admission, he had massive hemoptysis and died while in the ward. The second patient collapsed and died while getting on a train to visit relatives. At autopsy, rupture of the descending thoracic aorta with massive hemothorax was diagnosed. The third patient died at 44 postoperative months of sudden cardiac death, as revealed by the medical records of his general practitioner. To avoid underestimation of stent-graft-related complications, we considered this death to be procedure related. The fourth patient had a long-standing history of plasmacytoma and died of this concomitant illness 14 months after stent-graft placement. This death was not stent-graft related. In the surgical group, there was only 1 late death; this was due to a non-procedure-related cause. An 81-year-old woman had pneumonia and died 28 months after surgery.

TABLE 2. Postoperative outcomes of 60 patients with acute rupture of the descending thoracic aorta

Characteristic	Early		Late		Total	
	Stent	Surgery	Stent	Surgery	Stent	Surgery
Mortality	3.1%	17.8%	12.5%	3.6%	15.6%	21.4%
Procedure-related death	3.1%	17.8%	9.4%	0%	12.5%	17.8%
Paraplegia	0%	3.6%	3.1%	0%	3.1%	3.6%
Stroke	3.1%	0%	0%	0%	3.1%	0%
Endovascular leak	6.2%	—	9.4%	—	15.6%	—
Access failure	6.2%	—	0%	—	6.2%	—
Reintervention	3.1%	10.7%	6.2%	0%	9.3%	10.7%

Reintervention also included reexploration for bleeding and conversion to open surgery.

Figure 2. Actuarial time-related mortalities for endovascular and surgical treatment. cum., Cumulative.

Morbidity

In the surgical group, 3 patients (10.7%) required early reexploration for bleeding. In the endovascular group, 1 patient was reexplored surgically early after the intervention. A large, left-sided hemothorax had not been drained during the procedure, and empyema subsequently developed. During reexploration, as the empyema was removed, sudden bleeding occurred as one of the bare springs protruded through the aneurysmal sack. The bleeding was successfully oversewn with pledgeted 4-0 Prolene sutures.

There was one perioperative case of paraplegia (1.9%) in the surgical group and none in the endovascular group. Paraplegia this patient became evident when the patient was awakening from anesthesia, despite the presence of a cerebrospinal fluid drain. At 24 postoperative months, 1 patient in the endovascular group showed evidence of a distal endovascular leak, which was treated by deployment of a second stent graft. This patient had paraplegia develop on the second postoperative day. A cerebrospinal drain was placed immediately, but the paraplegia was not reversible. In the endovascular group, there was 1 case of perioperative

traumatic brain injury in a patient with a traumatic rupture of the descending thoracic aorta. This patient had been in a road traffic accident and had multiple injuries, including his cranium. On admission he was already intubated, so we do not know his neurologic status before the intervention.

Perioperatively, there were two distal type 1 endovascular leaks (6.2%) that were diagnosed at discharge from the hospital. After 6 months, both endovascular leaks had sealed spontaneously, without the need for further intervention. At late follow-up (24, 33, and 36 postoperative months), another 3 patients had type 1 endovascular leaks. Two patients had proximal leaks and 1 had a distal leak. One patient with a proximal endovascular leak 33 months after intervention had conversion to open surgery. No further endovascular intervention was possible. The stent graft was removed (Figure 1) through a left-sided thoracotomy, and the interposition of a Dacron polyester fabric tube graft carried out. Reintervention was not possible, because the left subclavian artery had already been overstented at the initial intervention. The courses of the 2 other patients with late endovascular leaks have already been described.

In the endovascular group, there were 2 cases of access failure (6.2%) caused by small caliber of the iliac vessels. One of these patients died during the procedure. The second patient, with a perforated type B dissection, was stabilized and discharged from the hospital on medical therapy. Her old age (82 years) and severe concomitant diseases (chronic obstructive pulmonary disease, hypertension, chronic renal failure) rendered her a high-risk candidate for open surgery. Eighteen months after discharge, the patient died at home. An autopsy was not performed.

Two patients in the endovascular group had late thrombosis of the left subclavian artery. In both patients, the left subclavian artery had been overstented during the initial intervention.

A summary of all postoperative outcomes is provided in Table 2.

Discussion

The treatment of acute lesions of the descending thoracic aorta in an emergency setting remains a great challenge. Despite widespread use of standardized treatment protocols, high perioperative morbidity and mortality limit the success of the conventional open surgical approach.^{2,3} Associated severe comorbidity is common in this group of patients and significantly influences the early outcome. This is illustrated by Crawford and colleagues,⁴ who reported a 30-day mortality for ruptured aneurysms of the descending thoracic aorta in low-risk patients of 12% but a mortality of 44% in patients with severe medical comorbidities. Debilitating postoperative morbidity such as paraplegia after emergency surgery on the thoracic aorta continues to occur at a rate of 2.9% to 25%.^{2,3,5,6} High rates of respiratory insufficiency, renal failure, and the need for reexploration for bleeding are also common after the conventional surgical approach.^{7,8}

In an effort to improve the perioperative outcomes of patients, endovascular stent grafting of the thoracic aorta was introduced in the early 1990s.^{9,10} Safety and technical feasibility of this approach were soon established and improved, as demonstrated by short-term results for both the elective and emergency settings.¹¹⁻¹³

Although perioperative and short-term results of endovascular stent grafting of the thoracic aorta were encouraging, few midterm and long-term follow up data are available. The first report of patients with complete 7-year follow-up was published by Alric and colleagues.¹⁴ They found that for the repair of abdominal aortic aneurysms, despite acceptable short-term results, stent grafts failed to protect patients from abdominal aortic aneurysm-related death. Additionally, they reported a high rate of late complications, with 49% of the patients having endovascular leaks and a proximal stent migration rate of 56.5%. These findings raise the question whether lasting protection from

procedure-related death is provided by stent grafts deployed in the thoracic aorta.

In our series of patients who underwent emergency repair of their lesions of the thoracic aorta, we achieved superior short-term results with endovascular stent grafts relative to conventional open surgery, as reported previously.¹ At a mean follow-up of 36.4 ± 12.8 months, however, the picture had changed somewhat. Actuarial time-related survival at 4 years was 72.9% in the endovascular group, compared with 78.6% in the open surgical group (Figure 2). It is noteworthy that in the surgical group the only death was due to coexisting disease. In the endovascular group, only 1 of 4 deaths was caused by coexisting disease; the other 3 deaths were related to the treated pathologies of the descending thoracic aorta. Additionally, 9.4% of patients had late endovascular leaks, requiring reintervention. One of these patients had paraplegia develop after a second stent graft was placed to seal a distal endovascular leak, the second patient required conversion to open surgery, and the third patient had a rupture of his thoracic aorta. Thus in our series the incidence of late endovascular leaks was always associated with severe subsequent complications. Our findings show a trend toward increased procedure-related mortality and morbidity in the endovascular group observable at 4 years. Similar midterm results were reported by other groups after endovascular stent grafting of acute and elective lesions of the descending thoracic aorta.

Demers and colleagues¹⁵ analyzed a cohort of 103 patients who underwent endovascular stent-graft repair of the thoracic aortic aneurysms. Perioperative mortality was 9%, and overall mortality at 5 years was 51%. They pointed out that 5-year mortality among good surgical candidates (22%) was superior to that among patients judged not to be suitable open surgery candidates (69%). Overall freedom at 5 years from stent-graft-related complications, including endovascular leaks and aortic intervention, was 56%. Very importantly, Demers and colleagues¹⁵ reported late rupture in 9% of the patients at 5 years and 20% at 8 years. In our series, 6.2% of patients ($n = 2$) also had late ruptures of thoracic aortic aneurysms, with evidence of an endovascular leak in 1 case. Orend and associates¹⁶ reported their 6-year experience with 74 patients after endovascular stent-graft repair for a variety of lesions of the descending thoracic aorta. Thirty-five percent of the procedures were emergencies. Overall mortality increased from 9.5% perioperatively to 17.6% at 6 years. In their cohort of patients, only 1 of the 5 late deaths was stent-graft related. The overall rate of endovascular leaks was 20.3%, and 4% of their patients required conversion to open surgical repair within the follow-up period. An unexpectedly high rate of late complications after stent-graft placement was also reported by Resch and coworkers.¹⁷ They observed an overall endo-

vascular leak rate of 22% and saw stent-graft migration in 43% of their patients.

The design of our study allowed us to compare directly the results of patients undergoing emergency endovascular stent grafting with those of a concurrent control group of patients undergoing open surgical repair. The comparability of the two groups was good, because all patients underwent the same diagnostic and management algorithms and were treated within the same period for similar lesions. Although this was not a randomized trial, we still believe that we can draw valid conclusions from our observations.

Our study showed that the minimally invasive nature of endovascular interventions improved early outcomes of patients treated for acute ruptures of the thoracic aorta relative to the open surgical approach. However, there was a distinct trend toward increased stent-graft–related mortality and morbidity at midterm follow-up, suggesting that stent grafts did not provide lasting protection from late procedure-related death. In comparison, open surgical graft interposition resulted in a lasting and stable repair, with no procedure-related deaths occurring at midterm follow up. Late stent-graft–related complications such as endovascular leaks and migration necessitating reintervention and conversion to open surgery remain worrisome and impair postoperative quality of life.

In conclusion, we believe that the question regarding long-term complications and durability of stent grafts still remains unanswered. At midterm follow-up, overall mortality and morbidity were comparable in stent graft and surgical groups. However, the progressive nature of stent-graft–related complications stresses the need for continued surveillance of these patients.

References

1. Doss M, Balzer J, Martens S, Wood JP, Wimmer-Greinecker G, Fieguth HG, et al. Surgical versus endovascular treatment of acute thoracic aortic rupture: a single-center experience. *Ann Thorac Surg.* 2003; 6:1465-70.
2. Miller OL, Calhoun JH. Acute traumatic aortic transection. In: Kaiser LR, editor. *Mastery of cardiothoracic surgery*. Philadelphia: Lippincott-Raven; 1997. p. 478-479.
3. Nienaber CA, Fattori R, Lund G, Dieckmann C, Wolf W, von Kodolitsch Y, et al. Nonsurgical reconstruction of thoracic aortic dissection by stent-graft placement. *N Engl J Med.* 1999;340:1539-45.
4. Crawford ES, Hess KR, Cohen ES, Coselli JS, Safi HJ. Ruptured aneurysm of the descending thoracic and thoracoabdominal aorta. Analysis according to size and treatment. *Ann Surg.* 1991;213:417-26.
5. Bui BT, Perreault P, Benko AJ. The complete guide: Talent endoluminal stent-graft system. Montreal, Canada: Campus St-Luc; 1995: 2-4, 43-45.
6. Lansman SL, Hagl C, Fink D, Galla JD, Spielvogel D, Ergin MA, et al. Acute type B aortic dissection: surgical therapy. *Ann Thorac Surg.* 2002;74:S1833-5; discussion S1857-63.
7. Mitchell RS. Stent grafts for the thoracic aorta: a new paradigm? *Ann Thorac Surg.* 2002;74:S1818-20; discussion S1825-32.
8. Doss M, Martens S, Hemmer W. Emergency endovascular interventions for ruptured thoracic and abdominal aortic aneurysms. *Am Heart J.* 2002;144:544-8.
9. Dake MD, Miller DC, Semba CP, Mitchell RS, Walker PJ, Liddell RP. Transluminal placement of endovascular stent-grafts for the treatment of descending thoracic aortic aneurysms. *N Engl J Med.* 1994;331: 1729-34.
10. Dake MD, Miller DC, Mitchell RS, Semba CP, Moore KA, Sakai T. The "first generation" of endovascular stent-grafts for patients with aneurysms of the descending thoracic aorta. *J Thorac Cardiovasc Surg.* 1998;116:689-704.
11. White RA, Donayre CE, Walot I, Lippmann M, Woody J, Lee J, et al. Endovascular exclusion of descending thoracic aortic aneurysms and chronic dissections: initial clinical results with the AneuRx device. *J Vasc Surg.* 2001;33:927-34.
12. Doss M, Balzer J, Martens S, Wood JP, Wimmer-Greinecker G, Moritz A, et al. Emergent endovascular stent grafting for perforated acute type B dissections and ruptured thoracic aortic aneurysms. *Ann Thorac Surg.* 2003;76:493-8.
13. Dake MD. Endovascular stent-graft management of thoracic aortic diseases. *Eur J Radiol.* 2001;39:42-9.
14. Alric P, Hinchliffe RJ, Wenham PW, Whitaker SC, Chuter TA, Hopkinson BR. Lessons learned from the long-term follow-up of a first-generation aortic stent graft. *J Vasc Surg.* 2003;37:367-73.
15. Demers P, Miller DC, Mitchell RS, Kee ST, Sze D, Razavi MK, et al. Midterm results of endovascular repair of descending thoracic aortic aneurysms with first-generation stent grafts. *J Thorac Cardiovasc Surg.* 2004;127:664-73.
16. Orend KH, Scharrer-Pamler R, Kapfer X, Kotsis T, Gorich J, Sunder-Plassmann L. Endovascular treatment in diseases of the descending thoracic aorta: 6-year results of a single center. *J Vasc Surg.* 2003;37: 91-9.
17. Resch T, Koul B, Dias NV, Lindblad B, Ivancev K. Changes in aneurysm morphology and stent-graft configuration after endovascular repair of aneurysms of the descending thoracic aorta. *J Thorac Cardiovasc Surg.* 2001;122:47-52.

Discussion

Dr R. Scott Mitchell (Stanford, Calif). Doss and colleagues have presented a nice series of patients with acutely symptomatic aneurysms, dissections, and traumatic transections. They opine that the favorable early results of endografts may be tempered by late complications in the endograft group. Although I have several reservations regarding the comparability of groups (in the article there is quite a significant age differential of 7 years and probably twice as many dissections in the stent-graft group), I must say that those do not mitigate the concerns about the long-term durability that were emphasized today. There were 4 late deaths in the stent-graft group, 3 definitely related to the aorta and 1 after dissection that required subsequent surgical repair. So I think this emphasizes our continued need for vigilance in these stent grafts, and I share some of the concerns. I do, however, have several questions, Dr Doss.

One was partially answered. Did these late endovascular leaks develop in patients with dissection, with aneurysm, or all of the above? Second, were any of the late-developing endovascular leaks related to the 2 early endovascular leaks that you noted at the time of implantation?

Dr Doss. First, the endovascular leaks occurred in all three categories. Actually, 1 was in a case of dissection, 1 in a case of ruptured aortic aneurysm, and 1 in a case of traumatic transection.

Regarding your second question, the early endovascular leaks that sealed spontaneously were not in the same patients who had late endovascular leaks. Those actually stayed stable.

Dr Mitchell. I think we now know that, especially in the diffuse aneurysmal patients, this is a diffuse disease that continues to progress even if the aneurysm is treated. We have seen the aorta

continue to elongate and some of these necks dilate. So knowing what we know now, that you should get as close to that left carotid as you can and come down as far distal toward the celiac as you can, is there anything that you could have done differently? Do you think that these 3 late endovascular leaks, which were catastrophic failures, might have been prevented?

Dr Doss. I'm afraid I have to say no, because when we looked at our elective series as well, we also had some late deaths, so these were just emergency cases presented. But there were also some late deaths in our elective series and late failure of endografts in patients who seem to have been very good candidates for endovascular treatment. As you said, the progressive nature of the aortic disease is a problem that we haven't really got an answer for yet.

Dr Mitchell. One late endograft revision resulted in paraplegia. Had that patient had previous abdominal aneurysm surgery?

Dr Doss. No, he hadn't. A stent graft was placed and a second stent graft was placed, but he did not have any aortic aneurysm

surgery. I know the literature, and I know that has been described, and we did look at it, but that wasn't the case.

Dr Mitchell. Finally, this article seems a tactical retreat from your previously published article, in which your results were quite supportive of stent-graft repairs. Did the additional 24 months of follow-up account for this tempering of enthusiasm? What is your current assessment of this technology and this particular application in the patient with acute symptoms?

Dr Doss. Our early published experience did make us enthusiastic, and we tried to be very aggressive in treating these patients with stent grafting, but it is true as you said that within the last 24 months we saw a rising number of complications in the emergency group. We also saw a rising number of complications in the elective group, and it has made us more cautious, especially in treating patients for whom the indication is not as clear. Basically, we are trying to look for an optimal patient to put a stent graft in, rather than trying to treat just any patient with a stent graft.