

THORACIC ENDOVASCULAR STENT GRAFT PLACEMENT: A CASE REPORT

Colleen M. Smith, CRNA, MS

Copley, Ohio

Endovascular stent grafting (EVSG) is a minimally invasive alternative to open repair of thoracic aortic aneurysms. It is useful in the treatment of thoracic aneurysms, dissections, and ruptures. Currently, the incidence of thoracic aortic aneurysms is 6:100,000 people. Comorbidities often include hypertension, coronary artery disease, chronic obstructive pulmonary disease, peripheral vascular disease, and cerebrovascular disease, and there often is a history of smoking. Without surgical intervention, a high risk of mortality exists, primarily due to aneurysm rupture.

Due to the complexity of performing open surgical repair of

the thoracic aorta and its associated morbidities such as paraplegia, renal failure, stroke, and prolonged ventilator support, new approaches to thoracic aneurysm repair are being investigated. When compared with open repair, stent grafting is a palliative rather than a curative treatment, and the risk of aneurysmal rupture still exists. This article describes a patient who underwent EVSG who had a history of abdominal aortic aneurysm repair and a known bovine arch.

Key words: Aortic aneurysm repair techniques, aortic aneurysms, thoracic endovascular stent graft repair, thoracic stent grafts.

Thoracic aortic aneurysm (TAA) is associated with atherosclerosis and degenerative changes in the aortic wall. The aneurysms can be fusiform or saccular in nature. A TAA is associated with a high morbidity if left untreated. Currently, the incidence is 6:100,000 people.¹ Unfortunately, aneurysms are usually asymptomatic and often are found incidentally. Endovascular stent graft (EVSG) placement for TAAs is an experimental procedure in the United States awaiting approval from the US Food and Drug Administration. The procedure is being investigated to treat multiple types of aneurysms, including those of the descending thoracic aorta, type B aortic dissection (Stanford), false aneurysms, penetrating ulcers, and aortic transection. It involves placement of a woven polyester tube covered by a metal webbing within the diseased vessel. The stent graft prevents continuous pressure on the aneurysm that could result in aneurysmal rupture or tearing by creating a new aortic lumen for blood flow. This article provides an overview of EVSG placement and discusses the indications, advantages, disadvantages, potential complications, and anesthetic implications of the procedure. A case report is presented.

Indications and contraindications for treatment of TAAs

Thoracic aortic aneurysms may often be asymptomatic. As the aneurysm expands, symptoms such as chest or back pain, primarily in the infrascapular area, may be present. Additional symptoms may be present such as hoarseness, coughing, wheezing, hemoptysis, or dysphagia due to involvement of adjacent structures

from compression or erosion.² Frequent comorbidities include coronary artery disease, diabetes mellitus, chronic obstructive pulmonary disease, hypertension, peripheral vascular disease, cerebrovascular disease, renal insufficiency, and hypercholesterolemia.^{2,3}

Bell and Reidy⁴ recommend surgical intervention in symptomatic thoracic aneurysms or asymptomatic thoracic aneurysms with diameters of more than 6 cm. Indications for surgical repair discussed by Neinaber et al⁵ include aortic diameter of more than 5.5 cm, a patent access vessel, false lumen expanding in size, and recurrent pain. Furthermore, aneurysms more than 1.5 to 2 times the normal transverse diameter also are recommended for treatment.² The risk of rupture of untreated TAAs ranges from 46% to 74% and has a 5-year survival rate of 9% to 13%.^{4,6}

Contraindications to EVSG placement are related to anatomic characteristics and include absence of or excessively large aneurysm neck, lack of aortic cuff for graft adherence, and poor peripheral arterial accessibility.^{4,6}

Advantages of EVSG placement

Stent graft placement has multiple advantages over open aneurysmal repair. Pulmonary complications are decreased due to the avoidance of a thoracotomy and one-lung ventilation used to gain exposure of the thoracic aorta. Avoiding a thoracotomy approach also decreases the potential for postoperative respiratory insufficiency. Avoidance of aortic cross-clamping reduces hemodynamic instability, metabolic stress, the incidence of myocardial infarction, congestive heart failure, renal failure, and thromboembolic complica-

tions.^{1,2,7,8} Morbidities of compromised end organ perfusion such as paraplegia, renal failure, and mesenteric ischemia also are reduced.

Another benefit of stent graft placement is avoidance of cardiopulmonary bypass, which can be associated with hypoperfusion of distal organs and adds length and complexity to the repair. Overall blood loss and the use of blood products is greatly reduced with stent grafting. This is especially important in the case of ruptured aneurysms, in which any further blood loss could result in shock.¹ Also, some of the primary sources of blood loss during open surgical repair, such as back-bleeding from branch arteries and bleeding from anastomotic sites are avoided.¹ The need for inotropic support for hemodynamic instability also is reduced.

Due to the minimally invasive nature of the procedure, less pain is associated, and recuperation time, including time spent in the intensive care unit, is reduced. The length of hospital stay is decreased to an average of 2 days following stent graft placement vs open repair, with a median length of stay of 15 days.^{9,10} The length of stay can vary greatly depending on the presence of comorbidities and increasing age of the patient population. Overall, the procedure may be more cost-effective than an open approach.

Limitations

A major limitation of the procedure is that it is a palliative treatment rather than a cure for TAAs. Furthermore, because the procedure is still experimental, thoracic stent graft devices are not commercially available, resulting in limited availability and accessibility. Limited numbers of providers have been trained in stent graft placement. Long-term follow-up studies are still being conducted.

Potential complications

The most common complication associated with EVSG is damage to the access artery, usually the femoral artery. This is due to the large size of the deployment device and coexisting atherosclerotic disease.^{4,7} Because the devices are not available for commercial use in the United States, grafts are custom-made. Hand-made devices can be rigid, increasing the risk of arterial perforation.⁴ Furthermore, a lack of flexibility can result in an endovascular leak. Perioperative complications noted by Ellozy et al³ include access vessel bleeding, ischemic events in lower extremities, inguinal lymphocele, neurologic complications (including 1 case of paraplegia), and vocal cord paralysis (occurring after left carotid-subclavian bypass grafting).

The use of the stent graft avoids the hemodynamic swings associated with open aneurysmal repair.

Because aortic cross-clamping is not required, the incidence of paraplegia is decreased to 3%, compared with an incidence in open surgical repair of 5% to 21%.^{1,3} The risk of paraplegia is primarily due to interruption of intercostal blood supply to the spinal cord.¹¹ The extent of interruption may be reduced with the endovascular approach. In an open approach, factors associated with paraplegia include the length of time the aortic cross-clamp is applied, number of intercostal vessels involved, and the presence of hypotension.⁷ Furthermore, this is dependent on the amount of collateral flow that has developed.⁷ The risk of paraplegia may be decreased when a cerebrospinal fluid lumbar drain is placed. The lumbar drain is used to decrease cerebrospinal fluid pressure, thus increasing spinal cord perfusion.

Prevention of hypotension, or perioperatively induced hypertension to increase spinal cord perfusion in patients at high risk for paraplegia, in addition to the administration of corticosteroids and mannitol, also may be beneficial.⁸ Epidural cooling, pharmacotherapy, left-sided heart bypass, motor-evoked potentials, and intercostal reimplantation techniques also may be used.¹¹ An increased risk of paraplegia exists in the presence of intraoperative hypotension, history of previous aortic surgery, and an increasing length of aortic coverage by the stent graft.⁴ Overall, the EVSG procedure helps to maintain aortic integrity, which in turn provides spinal artery protection. In addition, stent grafts deployed away from the T8 through L2 area reduce procedural time and avoid aortic cross-clamp and circulatory arrest, further decreasing the risk of developing paraplegia.⁵

Dake et al⁶ mention the potential for aneurysmal wall expansion outside of the graft. There is an incidence of 4% to 7% of cerebrovascular accident, which may be secondary to cerebral embolization from guide wire manipulation, excessive anticoagulation, or manipulation of the carotid or subclavian arteries.^{4,8} Mesenteric ischemia also has been reported due to visceral artery emboli during graft deployment.⁸ According to Gowda et al,¹ a postimplantation syndrome also can occur, resulting in fever, mild leukocytosis, and an elevated C-reactive protein level. C-reactive protein production can result in stimulation of the inflammatory process. Symptoms of postimplantation syndrome typically last 2 to 10 days and can be treated with nonsteroidal anti-inflammatory drugs.⁸

Additional delayed complications include stent graft migration, fracture, kinking, prolapse into the aneurysm site, infection, and endovascular leakage.¹ The possibility of continued aneurysm expansion and rupture also exists.

Preoperative imaging

Preoperative imaging includes chest radiography, spiral computed tomography, and angiography. Chest radiography may be used to evaluate baseline pulmonary status. Spiral computed tomography is used to determine proximal and distal aortic neck measurements and aneurysmal size. Angiography assesses aneurysm size, evaluates its relationship to the surrounding left subclavian and iliac arteries, and establishes vessel size, integrity, and blood flow to the femoral and iliac arteries.¹²

Anesthetic considerations

Placement of the EVSG can be performed under general, regional, or local anesthesia, with the latter two having the advantage of allowing for neurologic monitoring. Regional anesthesia options include epidural, single-shot spinal, and continuous spinal anesthesia.¹¹ Avoidance of general anesthesia can be desirable in patients with preexisting pulmonary conditions. Heparin, 300 to 400 U/kg intravenously, may be used to decrease the risk of embolism.

Hypotension may be induced with the administration of vasodilators and/or beta blockers before device deployment to decrease the mean arterial pressure. Multiple articles discuss titration of systolic blood pressure down to 50 to 60 mm Hg by using sodium nitroprusside until graft placement is achieved.^{5,6,12} This results in a reduction in arterial flow and subsequently decreases the risk of stent graft migration.⁶ Additional methods to help decrease stent graft migration include the induction of ventricular asystole through the use of pharmacological agents such as adenosine in high doses of 24 mg. If asystole is not achieved, the initial dose can be followed by boluses of 48 mg, 60 mg, and 90 mg until the desired effect is achieved.⁸ The effects are short-lived due to the short half-life of adenosine of less than 10 seconds. Sedation with propofol (1-2 mg/kg) or etomidate (0.1-0.2 mg/kg) before administration of adenosine has been recommended to increase patient comfort.⁸ Electrical methods to induce ventricular fibrillation such as rapid ramp pacing or alternating current administered through pacing electrodes can be used.⁸

Transesophageal echocardiography can be a useful tool during EVSG placement by providing views of the aorta and location of the guide wires and stent graft device before its deployment.⁸ In addition, transesophageal echocardiography can help determine if intercostal arteries are occluded and provide continuous evaluation of cardiac function.⁸

An arterial line, pulmonary artery catheter (based on cardiac history), central venous monitoring, and

external temporary pacer pads are intraoperative monitoring devices that should be considered. Venous access should be available through a large-bore intravenous catheter, in addition to the availability of a rapid infusion device should rapid fluid resuscitation be required.

Case report

A 75-year-old woman sought care because of a sudden onset of pain in the left shoulder that she had experienced for 4 days and subsequent development of shortness of breath. Her medical history was significant for hypertension, severe cardiomyopathy with an ejection fraction of 25%, abdominal aortic aneurysm, TAA (diagnosed 2 years before admission), asthma, severe chronic obstructive pulmonary disease, history of tobacco use, and type 2 diabetes mellitus.

Initial computed tomography studies demonstrated the presence of a TAA, with follow-up magnetic resonance angiography imaging revealing enlargement of the patient's proximal descending TAA to 8.2 cm in size. A bovine arch, which occurs when the innominate and left carotid arteries share a common origin from the aortic arch and has a 10% incidence, also was present.¹³ Due to her comorbidities, it was thought that she was not a candidate for open thoracotomy repair. On admission to the hospital, a labetalol drip was used preoperatively for blood pressure control. Her surgical history included an open abdominal aneurysm repair 4 years earlier.

The patient agreed to undergo placement of a thoracic EVSG. A spinal drain was placed using sterile technique by the anesthesiologist and opened to a pressure of 10 cm H₂O for prevention of spinal cord ischemia. Induction of a general anesthetic was performed using etomidate, 20 mg, and rocuronium bromide, 40 mg. Anesthesia was maintained throughout the procedure by using a balanced technique including fentanyl, midazolam, and isoflurane at more than 0.5% minimum alveolar concentration and cisatracurium for neuromuscular blockade.

The patient was heparinized with 10,000 U, and an activated clotting time was checked every 30 minutes to maintain a value of more than 250 seconds. A second dose of heparin 2,500 U, was administered approximately 3 hours after the initial dose for an activated clotting time of 292. Access for the stent graft device initially was obtained via the common femoral artery, using the ileofemoral system. The device was advanced to just before the innominate artery. The second component of the graft could not be advanced due to a flap of intima requiring the placement of an ileofemoral conduit. Ultimately, a

total of 3 EVSG components were placed successfully.

During the ileofemoral conduit placement, clamping of the common iliac arteries was required, resulting in metabolic acidosis.

Arterial blood gases obtained approximately 4 hours into the procedure demonstrated the following values: pH, 7.20; pO_2 , 103 mm Hg; pCO_2 , 44 mm Hg; HCO_3^- , 17 mEq/L; base excess, -10; and oxygen saturation, 98%. Ventilator settings were as follows: tidal volume, 520 mL; respiratory rate, 8 breaths per minute; FiO_2 , 0.8; SpO_2 , 98%; and $ETCO_2$, 29 mm Hg. Corrective treatment included 2 ampules of sodium bicarbonate.

The patient's initial hemoglobin level was 11.7 g/dL, which decreased to 9.3 g/dL after a 500-mL blood loss. Results of repeated arterial blood gas measurement 1 hour later were as follows: pH, 7.34; pO_2 , 91 mm Hg; pCO_2 , 38 mm Hg; HCO_3^- , 20; base excess, -5; and oxygen saturation, 98%.

Intraoperative blood loss totaled 1,100 mL, which was replaced with 3 units of packed red blood cells and 500 mL of cell saver. Total crystalloid received was 3,700 mL. Urine output decreased after approximately 4 hours, and mannitol, 25 g, was administered and dopamine started at 5 μ g/kg per minute. Urine output subsequently increased to more than 60 mL/h.

At the end of the procedure, protamine, 40 mg, was used to reverse the heparin. Due to the patient's severe preexisting pulmonary disease, she was taken to the intensive care unit with the endotracheal tube in place and was extubated on the first postoperative day.

The procedure required an extended surgical time of approximately 7 hours compared with the typical surgical time of 2 to 4 hours due to anatomic difficulties in placing the graft. The need for an ileofemoral conduit and bypass required the clamping of the common iliac artery, subsequently resulting in metabolic acidosis that was treated with sodium bicarbonate. The patient also required the administration of blood products during the procedure due to an estimated blood loss of 1,100 mL and a hemoglobin level of 9.3 g/dL. A prolonged hospital stay of 13 days occurred due to respiratory failure postoperatively. This resulted in reintubation on postoperative day 4 due to the presence of hypoxemia, respiratory acidosis, and lethargy. Discontinuation of the lumbar drain was delayed due to altered coagulation status (elevated prothrombin time of 14-16.3 seconds and an international normalized ratio of 1.3-1.6). When the coagulation status normalized (prothrombin time, 12.0; international normalized ratio, 1.1), the drain was discontinued on postoperative day 5. The patient did

not have any neurologic deficits or renal failure associated with the surgical procedure. Discharge to a nursing facility occurred on postoperative day 13.

Discussion

Palliative treatment of a TAA with an EVSG prevents the need for a thoracotomy, decreasing the potential for postoperative respiratory insufficiency and pain and decreasing the hospital length of stay and cost. It also avoids the hemodynamic swings associated with aortic cross-clamping and reduces the associated risks of paraplegia, myocardial infarction, congestive heart failure, renal failure, and thromboembolic complications.^{1,2,7} To further help avoid the risk of spinal cord ischemia, a lumbar drain can be placed and opened to 10 cm H_2O .

Before stent graft deployment, the mean arterial pressure needs to be reduced to prevent downstream migration. This can be accomplished through the administration of short-acting vasodilator agents such as sodium nitroprusside. Beta blockers such as esmolol or labetalol also can be considered.

The potential for an alternative approach for graft placement exists if the graft cannot be advanced successfully by using the femoral artery. This can result in prolonged procedure time, increased risk of blood loss, and the potential for metabolic alterations if clamping is required.

Placement of an EVSG is still an experimental procedure; however, it is likely that it will be used on a more frequent basis in the future after long-term follow-up studies are conducted. This article was written to familiarize anesthesia providers with this alternative treatment for TAAs and its related potential complications.

REFERENCES

1. Gowda RM, Misra D, Tranbaugh RF, Ohki T, Khan IA. Endovascular stent grafting of descending thoracic aortic aneurysms. *Chest*. 2003;124:714-719.
2. Mitchell S, Miller DC, Dake MD. Stent-graft repair of thoracic aortic aneurysm. *Semin Vasc Surg*. 1997;10:257-271.
3. Ellozy SH, Carroccio A, Minor M, et al. Challenges of endovascular tube graft repair of thoracic aortic aneurysm: midterm follow-up and lessons learned. *J Vasc Surg*. 2003;38:676-683.
4. Bell RE, Reidy JF. Endovascular treatment of thoracic aortic disease [editorial]. *Heart*. 2003;89:823-824.
5. Nienaber CA, Fattori R, Lund G, et al. Nonsurgical reconstruction of thoracic aortic dissection by stent-graft placement. *N Engl J Med*. 1999;340:1539-1545.
6. Dake MD, Miller C, 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;331:1729-1734.
7. Kasirajan K, Marek J, Langsfeld M. Endovascular management of acute traumatic thoracic aneurysm. *J Trauma*. 2002;52:387-390.
8. Kahn RA, Moskowitz DM, Marin M, Hollier L. Anesthetic considerations for endovascular aortic repair. *Mt Sinai J Med*. 2002;69:57-67.

9. Greenberg RK. Endovascular therapy or conventional vascular surgery? A complex choice. *Cleveland Clin J Med*. 2003;70:1038-1054.
10. Huynh TT, Miller CC III, Estrera AL, Sheinbaum R, Allen SJ, Safi HJ. Determinants of hospital length of stay after thoracoabdominal aortic aneurysm repair. *J Vasc Surg*. 2002;35:648-653.
11. Kim SS, Leibowitz AB. Endovascular thoracic aortic aneurysm repair using a single catheter for spinal anesthesia and cerebrospinal fluid drainage. *J Cardiothorac Vasc Anesth*. 2001;15:88-89.
12. Sumba CP, Dake MD. Endoluminal stent-grafting in the thoracic aorta. In: Chuter TA, Donayre CE, White RA, eds. *Endoluminal Vascular Prosthesis*. New York, NY: Little, Brown and Co; 1995:153-171.
13. Shaw JA, Gravereaux EC, Eisenhauer AC. Carotid stenting in the bovine arch. *Catheter Cardiovasc Interv*. 2003;60:566-569.

AUTHOR

Colleen M. Smith, CRNA, MS, is a staff nurse anesthetist at Cleveland Clinic in Cleveland, Ohio. She was a student in the Oakland University/Beaumont Hospital Nurse Anesthesia program in Royal Oak, Mich, at the time this article was written. Email: smithc14@ccf.org

ACKNOWLEDGMENTS

I thank Michael Faulkner, MD, anesthesiologist at William Beaumont Hospital; Karen Zaglaniczny, CRNA, PhD, FAAN, director of Graduate Program of Nurse Anesthesia at William Beaumont Hospital; and Rob Smith, CRNA, at William Beaumont Hospital.