# Endovascular aortic aneurysm repair

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2012

chapter 4

# Direct videoscopic approach to the descending thoracic aorta for aortic arch endograft delivery: evaluation in a porcine model

*Journal of Endovascular Therapy 2007 14: 39-43*

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## ABSTRACT

**Objective:** To examine the feasibility of a direct videoscopic approach to the descending thoracic aorta for endograft delivery to the aortic arch.

**Methods:** A double purse-string suture was placed on the aorta of 3 pigs via a thoracoscopic approach. Subsequently, the aorta was cannulated in the center of the purse-string. A 22-F delivery catheter was advanced under fluoroscopic control over a guidewire via a trocar into the proximal aorta. After deployment of a tubular endograft, the catheter was withdrawn from the aorta while simultaneously tightening the purse-string suture, without aortic cross clamping. The outcome was evaluated by post implant angiography and autopsy results.

**Results:** The procedure was successfully completed in all animals, with a mean total procedure time of 126 minutes (range 118–137). Mean endograft implantation time from needle puncture to catheter extraction was 27 minutes (range 21–37). Hemostasis was obtained in all animals after withdrawal of the delivery catheter and tightening the purse-string suture. The mean blood loss was 143 mL (range 80–220). Autopsy proved all purse-string sutures to be adequately placed and all endografts deployed in the correct position.

**Conclusion:** A direct videoscopic approach to the descending thoracic aorta proved a feasible technique for endograft delivery to the aortic arch in a porcine model.

## Introduction

Endovascular repair of thoracic aortic aneurysms (TAAs) has emerged as a viable alternative to open surgical repair.[1,2] However, its application has been limited for the most part to TAAs in the descending thoracic aorta. Due to its anatomy, the aortic arch remains a very difficult area for endograft delivery. At this level, the aorta is wide and tortuous and contains essential branch vessels for blood flow to the brain and arms.

Fenestrated and branched endografts are currently being developed for exclusion of aortic arch aneurysms with branch vessel involvement. Although several studies have reported successful repair of aortic arch aneurysms with these types of endografts,[3–5] the procedures have proven to be complex and time-consuming. Endovascular TAA repair routinely utilizes the femoral arteries for access, but the long distance between the access point and the target site makes it difficult to maneuver the large-caliber delivery sheaths, especially in patients with tortuous, calcified, or stenotic iliac arteries.

The aim of this study was to examine the feasibility of a direct videoscopic approach to the descending thoracic aorta for endograft delivery to the aortic arch. As an alternative to the femoral approach, this technique may benefit the delivery of fenestrated and branched endografts.

## Methods

Following 2 pilot studies for adjustments to materials and techniques, 3 female Yorkshire pigs weighing a mean 92 kg (range 83–97) were obtained from a single vendor and underwent a 5-day preoperative conditioning period. All animals underwent the same operative procedure in 3 consecutive experiments. Experiments were conducted using the guidelines published in the Guide for the Care and Use of Laboratory Animals (NIH publication 85-23, revised 1985). The study protocol was approved by our institution's Animal Care and Use Committee.

The animals were sedated with intravenous fentanyl (5 g/kg) and ethomidate (0.25 mg/ kg) before endotracheal intubation. A mixture of intramuscular ketamine (10 mg/kg), midazolam (0.2 mg/kg), and atropine (0.01 mg/kg) was administered, and general anesthesia was continued with intravenous fentanyl (5 g/kg/h), midazolam (0.125 mg/kg/h), and pancuronium (0.20 mg/kg/h) and inhaled isoflurane (2.4%).

Tidal volume was initially set at 20 mL/kg and the respiratory rate at 12 per minute. These initial parameters were modified after serial blood gas measurements to keep the pCO2 between 25 and 35 mmHg and the pH within normal limits. Right-sided jugular venous and carotid arterial accesses were obtained prior to the procedure. The electrocardiogram, blood pressure, blood gases, urine output, transcutaneous oxygen saturation, and body temperature were monitored throughout the entire procedure.

At operation, endograft implantation and total procedure times and total blood loss were monitored. The pigs were placed in a left supine position, and a Reliant balloon catheter (Medtronic Inc, Santa Rosa, CA, USA) was inserted into the left main bronchus under fluoroscopic control. The balloon was inflated to block the left main bronchus, creating selective right-lung ventilation. The animals were then placed in a 30° ventral position (Fig. 1). A 12-mm port was introduced into the 8th intercostal space, and a 30-mm thoracoscope was introduced. Under direct visualization from within, two 5-mm dissecting ports were inserted in the 6th and 9th intercostal spaces. An additional 12-mm port was placed into the 11th intercostal space to accommodate the endovascular equipment.

After insertion of the thoracoscope, the pleura overlying the thoracic aorta at the site of intended cannulation was removed, and a double purse-string suture (4.0 Prolene) with 2 felt pledgets was placed. Without tightening the purse-string, both suture ends were guided through the right dissecting port and secured outside the body. In case of bleeding from the access point, 2 endoscopic aortic clamps were at hand.

After rearranging the working space (Fig. 2), a specifically designed extracorporeal puncture needle followed by a 0.035-inch guidewire (Rosen Curved; Cook Inc., Bloomington, IN, USA) were inserted into the endovascular port in the 11th intercostal space. Following systemic heparinization (5000-unit bolus and 10,000 U/h continuously), the aorta was punctured in the center of the purse- string suture, and the guidewire was advanced into the proximal aorta. The puncture needle was retracted and replaced by a sizing catheter (Arous; Cook Inc.) for digital subtraction angiography. The diameter of the aorta and the distance between the orifice of the left carotid artery and the cannulation area were determined angiographically. Subsequently, a 0.035-inch stiff guidewire (Back-up Meier; Boston Scientific, Natick, MA, USA) was inserted, and the sizing catheter was re- placed by a 22-F Coiltrac delivery system (Medtronic Vascular) containing an appropriately sized (22-70 mm) tubular Talent endograft (Medtronic Inc). Under fluoroscopic control the delivery system was advanced over the guidewire (Fig. 3), and the endograft was deployed just distal to the left carotid artery. The catheter was withdrawn while simultaneously tying the purse-string suture with assistance of a knot pusher. The entire procedure was performed under visual control through the thoracoscope. Finally, the pigs were euthanized with an overdose of potassium chloride, and an autopsy was performed to evaluate device positioning and suture placement.

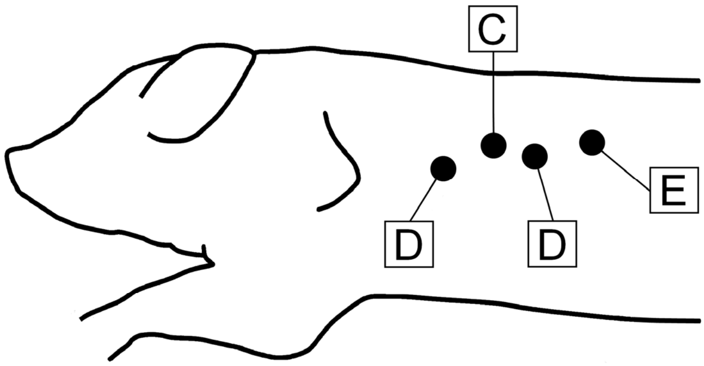


**Figure 1:** Side view of the trocar placement. The pig is placed in a 30° ventral position, and the camera trocar (C) is placed in the 8th intercostal space. Two dissection trocars (D) are positioned in the 6th and 9th intercostal spaces, and the endovascular port (E) is placed into the 11th intercostal space.

## Results

The procedure was successfully completed in all 3 animals. After insertion of the thoracoscope, the entire descending aorta immediately came into view without any dissection, retraction, or insufflation. Angiography revealed an aortic diameter of 20 mm in all animals. The distance between the orifice of the left carotid artery and the area of cannulation was □90 mm. The mean endograft implantation time from needle puncture to catheter ex- traction was 27 minutes (21–37). Hemostasis was obtained in all animals after withdrawal of the delivery catheter and simultaneous tightening of the purse-string. No aortic cross clamping was performed. Mean blood loss was 143 mL (range 80–220). Mean total procedure time was 126 minutes (range 118–137). Autopsy proved all purse-string sutures to be adequately placed and all endografts deployed in the correct position.

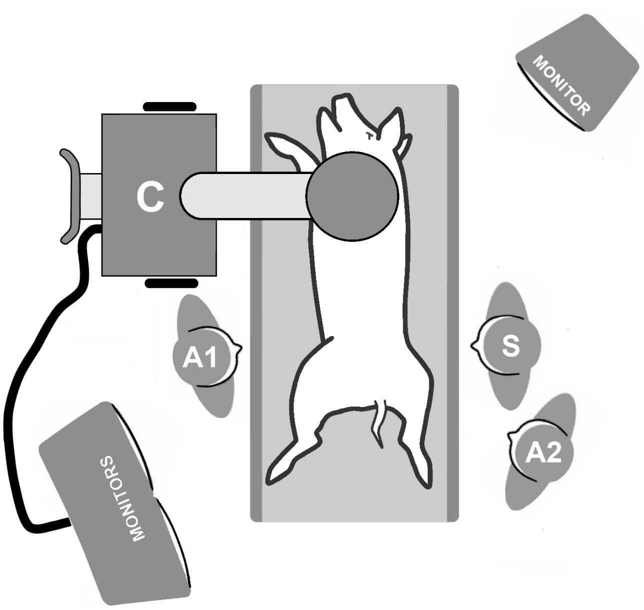


**Figure 2:** Operating room setup for the endovascular procedure. After positioning the C-arm (C), the surgeon (S) and the first assistant (A1) start the endovascular procedure. Meanwhile, the second assistant (A2) attends the thoracoscope to provide visual control of the access point.

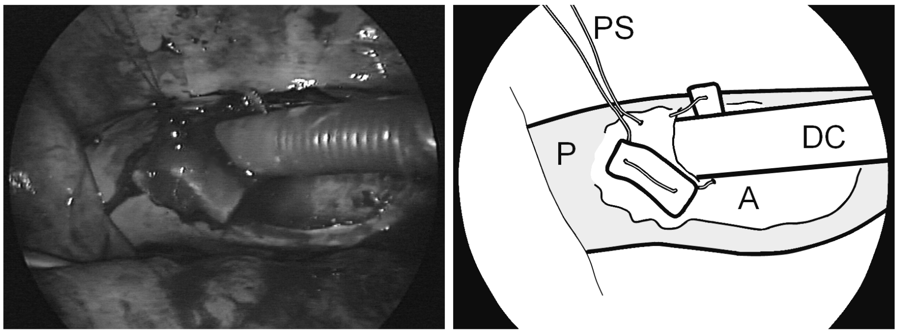


**Figure 3:** The pleura (P) is partially removed from the aorta (A), and a double purse-string suture (PS) with 2 felt pledgets is placed. The delivery catheter (DC) is advanced into the aorta.

## Discussion

The development of fenestrated and branched aortic endografts has made it possible to treat aneurysms of the aortic arch and maintain flow to essential branch vessels.[3–5] However, the procedures are technically demanding and time-consuming. Moreover, maneuverability of the usually large-caliber delivery catheters is difficult from a femoral access point, particularly in patients with tortuous, calcified, or stenotic iliac arteries.

A number of techniques are available to circumvent femoral access during endovascular aortic aneurysm repair. Several studies describe direct sheath placement in the aorta or iliac arteries by means of surgical exposure, with or without the use of conduits.[6–8] However, the surgical approach in these procedures negates the minimally invasive nature of endovascular therapy.

Over the past decade, videoscopic techniques in vascular surgery have progressed from laparoscopically-assisted to totally laparoscopic procedures.[9–12] The latest developments combine these endoscopic experiences with current endovascular techniques into so-called hybrid procedures with direct vascular access to the aorta for the insertion of an endograft.[13] Formichi et al.[14] described a successful laparoscopic approach to the abdominal aorta for thoracic endograft deployment in a porcine model, but as in other laparoscopic vascular procedures, exposure of the aorta presents technical difficulties. The aorta is exposed either via a transperitoneal or a retroperitoneal approach or a combination of both.[15,16] The transperitoneal route is complicated by the need to keep the intestines out of the operative field, while it is technically challenging to maintain a good working space in the retroperitoneal approach. The retroperitoneal space easily collapses with suction, and even a small hole in the peritoneal flap results in CO2 leakage or intrusion of bowel with loss of visibility. A combination of both approaches, the apron technique, in which a peritoneal flap is attached to the anterior abdominal wall, offers an adequate working space without the drawbacks of the trans- and retroperitoneal approaches. However, it has also proven to be a tedious and time-consuming technique.[15,17,18]

For this study, we devised a thoracoscopic approach to the aorta for endograft delivery. This route has the advantage of easy dissection, requiring only removal of the pleura over the aorta. On the other hand, this approach necessitates selective exclusion of the left lung. However, the descending aorta immediately came into view after introducing the thoracoscope, without insufflation or retraction.

During pilot studies, achieving hemostasis after withdrawal of the delivery catheter presented the biggest challenge. Placing a double purse-string suture with 2 felt pledgets prior to the arterial puncture proved a reliable method to limit blood loss. Moreover, no cross clamping of the aorta was needed. In view of the fact that we operated on healthy pigs, the clinical application of the proposed technique may have potential complications when utilized in patients with heavily diseased descending aortas. In case of a massive hemorrhage from the thoracic aorta, conversion to a thoracotomy might be the only solution.

For this study, the emphasis was on cannulation of the aorta through a thoracoscopic approach, as well as achieving hemostasis after withdrawal of the delivery catheter. Endograft deployment was considered a secondary goal, so we used only tubular endografts covering the left subclavian artery. Nevertheless, in our opinion, this approach will benefit the delivery and deployment of fenestrated and branched endografts during the repair of complex aortic arch aneurysms. The short, direct approach could provide better catheter handling and maneuverability, as well as easy endograft deployment.

## Conclusion

A direct videoscopic approach to the descending thoracic aorta proved an excellent technique for endograft delivery to the aortic arch in a porcine model. Additional studies should be performed to examine the broader applicability of this technique, as well as its potential benefit to the delivery and deployment of fenestrated and branched endografts.

## References

1. Criado FJ, Abul-Khoudoud OR, Domer GS, et al. Endovascular repair of the thoracic aorta: lessons learned. Ann Thorac Surg. 2005; 80: 857–63.
2. Rousseau H, Bolduc JP, Dambrin C, et al. Stent-graft repair of thoracic aortic aneurysms. Tech Vasc Interv Radiol. 2005; 8: 61–72.
3. Saito N, Kimura T, Toma M, et al. Images in cardiovascular medicine. Endovascular treatment of a giant aortic arch aneurysm with a triple-branched stent graft. Circulation. 2005; 112: e151–e2.

4. Wang ZG, Li C. Single branched aortic endograft for treating Stanford type B aortic dissections in proximity to the left subclavian artery. J Endovasc Ther. 2005; 12: 588–93.
5. Inoue K, Hosokawa H, Iwase T, et al. Aortic arch reconstruction by transluminally placed endovascular branched stent graft. Circulation. 1999; 100 (Suppl 19): II 316–II 21.
6. Macdonald S, Byrne D, Rogers P, et al. Common iliac artery access during endovascular thoracic aortic repair facilitated by a transabdominal wall tunnel. J Endovasc Ther. 2001; 8: 135–8.
7. Carpenter JP. Delivery of endovascular grafts by direct sheath placement into the aorta or iliac arteries. Ann Vasc Surg. 2002; 16: 787–90.
8. Bernier PL, Turcotte R, Normand JP, et al. Video-assisted mini-thoracotomy for thoracic stent-graft implantation: a novel vascular access for endovascular repair. J Endovasc Ther. 2004; 11: 180–2.
9. Dion YM, Katkhouda N, Rouleau C, et al. Laparoscopy-assisted aortobifemoral bypass. Surg Laparosc Endosc. 1993; 3: 425–9.
10. Kolvenbach R, Schwierz E, Wasilljew S, et al. Total laparoscopically and robotically assisted aortic aneurysm surgery: a critical evaluation. J Vasc Surg. 2004; 39: 771–6.
11. Wisselink W, Cuesta MA, Gracia C, et al. Robot-assisted laparoscopic aortobifemoral bypass for aortoiliac occlusive disease: a report of two cases. J Vasc Surg. 2002; 36: 1079–82.
12. Coggia M, Di Centa I, Javerliat I, et al. Total laparoscopic abdominal aortic aneurysms repair. J Cardiovasc Surg (Torino). 2005; 46: 407–14.
13. Kolvenbach R, Lin J. Combining laparoscopic and endovascular techniques to improve the outcome of aortic endografts. Hybrid techniques. J Cardiovasc Surg (Torino). 2005; 46: 415–23.
14. Formichi M, Renier JF. A laparoscopic approach to the abdominal aorta for thoracic stent-graft deployment: evaluation in a porcine model. J Endovasc Ther. 2002; 9: 344–349.
15. Dion YM, Gracia CR. A new technique for laparoscopic aortobifemoral grafting in occlusive aortoiliac disease. J Vasc Surg. 1997; 26: 685–92.
16. Alimi YS, Hartung O, Orsoni P, et al. Abdominal aortic laparoscopic surgery: retroperitoneal or transperitoneal approach? Eur J Vasc Endovasc Surg. 2000; 19: 21–6.
17. Nio D, Diks J, Linsen MA, et al. Robot-assisted laparoscopic aortobifemoral bypass for aorto- iliac occlusive disease: early clinical experience. Eur J Vasc Endovasc Surg. 2005; 29: 586–90.
18. Ruurda JP, Wisselink W, Cuesta MA, et al. Robot-assisted versus standard videoscopic aortic replacement. A comparative study in pigs. Eur J Vasc Endovasc Surg. 2004; 27: 501–6.