An Experimental Study of a New Pull-through Technique for Aortic Arch Aneurysm in a Porcine Model

Hiroshi Ohtake, MD,* Junichiro Sanada, MD,† Hiroki Kato, MD,
Keiichi Kimura, MD,* Hiroshi Nagamine, MD,* Go Watanabe, MD,*
and Osamu Matsui, MD,† *Kanazawa, Japan*

A new pull-through technique for placement of the aortic arch stent-graft was developed. Self-expandable curved stents (Matsui-Kitamura stents) were used on 4 pigs. With use of the endoscopic system, the sheath insertion was performed at the ascending aorta. By this pull-through method from the ascending aorta to the femoral artery, the stent was deployed into the aortic arch. All stents were successfully deployed into the correct position, and they fitted into the curvature of the aortic arch wall. By this method, stent-grafting for aortic arch aneurysm is expected to be performed with more accuracy and safety.

Introduction

Aortic arch aneurysms are relatively frequent but are anatomically difficult for endovascular repair. Recent advances in medical technologies and techniques have tried to solve several problems. Recently we developed a curved stent-graft.[1-3] The flexibility of this stent-graft allows it to be fitted into the aortic curvature. Furthermore, we have performed transposition or bypass surgery of supraaortic arteries spontaneously. However, placement and deployment of these large, stiff, and inflexible devices can be extremely difficult despite use of a stiff guidewire in the normal pull-through technique from the right brachial artery to the femoral artery.[4] The stent-graft can be placed only into the relatively distal side of the aortic arch. In this study, we tried a new pull-through technique for the purpose of advancing a stent delivery system into the aortic arch.

Vasc Endovasc Surg 39:253–256, 2005

From the Division of Vascular Surgery, Departments of *General and Cardiothoracic Surgery and †Radiology, Kanazawa University School of Medicine, Kanazawa, Japan

Correspondence: Hiroshi Ohtake, MD, Department of General and Cardiothoracic Surgery, Kanazawa University School of Medicine, Kanazawa 920-8641, Japan
E-mail: ohtake@med.kanazawa-u.ac.jp

Methods

Self-expandable curved stents (Matsui-Kitamura;

M-K stent, Cathex, Kanagawa, Japan) measuring 20 mm in diameter and 80 mm in length were used. The framework of this MK stent was made of a single superelastic nitinol wire. The wire was wound in a spiral fashion around the circumference of a mandrel of the desired shape, diameter, and length. This stent could be deployed through an 8-Fr guide sheath (shuttle guiding system, Cook, Bloomington, IN, USA) with a pushing rod.

Four pigs weighing between 30 and 40 kg were treated according to the guidelines for the Care and Use of Laboratory Animals in Takaramachi Campus of Kanazawa University and Miyazaki Technology and Educational Center of Boston Scientific Japan Co, Ltd. Furthermore, in this study, not the stent-graft but the stent was used for protection of the animals.

The procedures were performed under general anesthesia with endotracheal intubation. Anesthesia was maintained by 40% NO_2 and sebofluren. The electrocardiography, heart rate, continuous blood pressure, and blood gases were monitored. Ringer's lactate solution was administered for hydration.

The animals were placed in the supine position. An angiographic catheter was placed in the ascending aorta via the right carotid artery for obtaining aortograms. The right femoral artery was punctured and an 8-Fr sheath (Medikit, Tokyo, Japan) was inserted. At the second or third parasternal intercostal space, a small incision was made. By using an endoscopic system (CF-Q2401, Olympus, Tokyo, Japan), we made a purse string suture for a 4-Fr sheath (Cathex, Kanagawa, Japan) insertion at the aortic root (Figure 1A, B). Through the sheath of the ascending aorta, a 0.035-inch, 260-cm-long hydrophilic guidewire was introduced, advanced, and drawn out of the femoral artery sheath to work the tug of wire. Heparin was administered intravenously (50 U/kg).

Under the pull-through technique, an 8-Fr guide sheath was introduced into the ascending aorta for delivery of the stent. Under fluoroscopic monitoring, the stent was advanced through the sheath with a stent pusher. The sheath was withdrawn while the stent pusher was held in place, releasing the proximal side of the stent in the ascending aorta (Figure 2A). After the stent deployment, the purse string suture was tightened, and the guidewire was pulled out of the aorta. The pigs were then sacrificed. The portion of the aorta containing the stent was harvested.

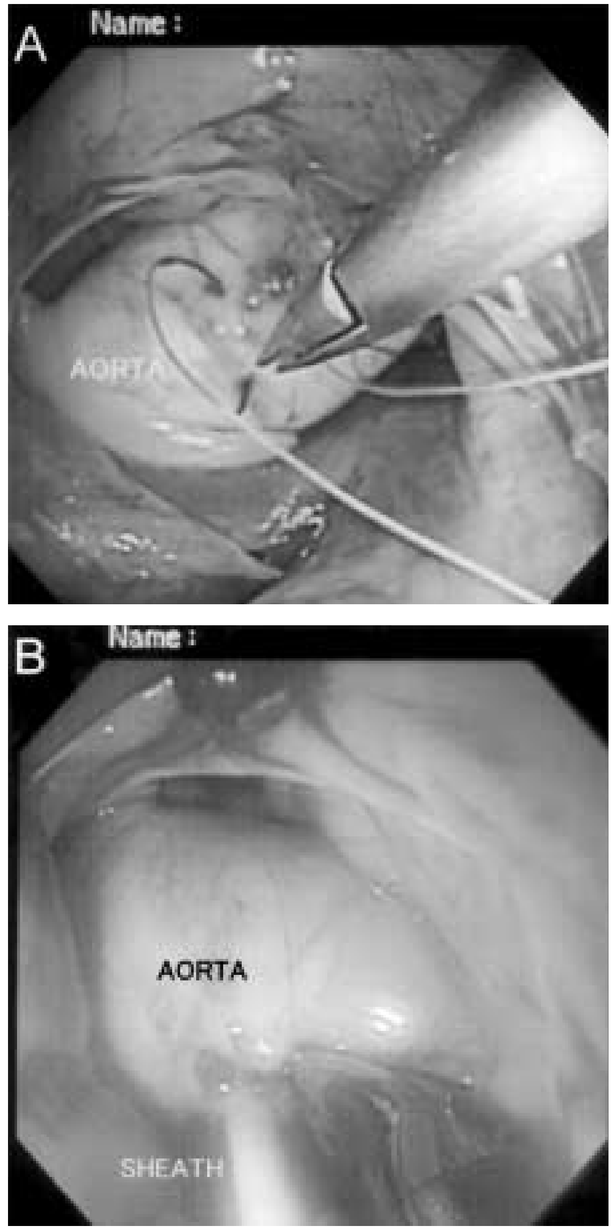

Figure 1. Intraoperative endoscopic findings. A. The purse-string suture was performed easily and safely. B. Through the 4 Fr sheath of the ascending aorta, the guidewire was introduced.

Results

The procedure was successfully completed in 4 pigs according to the established protocol. All stents were successfully deployed into the correct position; ie, the proximal side of the stent was positioned at the ascending aorta, and the stent fitted into the curvature of the aortic arch wall without any kinks (Figure 2B). In none of the animals did bleeding occur during aortic puncture or during insertion of the guidewires. No hemodynamic events occurred during the procedure. After restoration of the normal blood flow, visual inspection of the harvested aortic segments containing the stent-grafts confirmed correct positioning and deployment of the device in the thoracic aorta.

Figure 2. Intraoperative fluoroscopic findings. A. The M-K stent deployment was performed smoothly. B. A postdeployment angiograph showed that the stent fitted into the curvature of the aortic arch wall without any kinks.

Discussion

Stent-graft repair has become a new alternative method instead of surgical graft replacement for thoracic aortic aneurysms (TAA).[5] Recently, stent-graft repair for treatment not only of the descending aorta but also of the aortic arch was tried.[6] However, this procedure reportedly has some technical limitations.[7]

One of the most important problems was a sufficient fitting for the aortic wall. The TAAs frequently develop at the aortic arch, and the acute curvature or bending of the aorta makes stent-grafting for TAA a complicated procedure. Therefore, we have developed a new quality and character of the stent.[8] This M-K stent fits into the aortic arch and can thus be expected to minimize damage to the aortic wall. By using the J sheath, the curvature of the tip would automatically adjust to that of the aortic arch. This curved M-K stent-graft contributes to solving this problem. Furthermore, for revascularization of supraaortic arteries, we have successfully performed transposition or bypass surgery.

Another problem is the accurate deployment and placement of the stent-graft. Placement and deployment of these large (18 Fr to 27 Fr), inflexible devices can be difficult despite using a stiff guidewire in the normal pull-through technique. Deployment of even a self-expandable device is difficult because the ascending aorta moves with beating of the heart, but elective adenosine cardiac arrest during inflation has addressed this problem.[9] Even if the delivery system is appropriately positioned, once the inner sheath is removed, the delivery system straightens and no longer follows the curvature of the aortic arch. In the standard pull-through technique, exteriorizing the guidewire through the right brachial artery provides better device control, but the guidewire directs the stent-graft cephalad when lying within the transverse arch or the proximal descending aorta, preventing the stent-graft from being deployed along the arch curvature. Moreover, the brachial guidewire precludes device deployment in the ascending aorta because the device can be advanced only into the distal portion of the transverse arch.

Our new pull-through technique from the ascending aorta creates a stable guidewire position that follows the curvature of the aortic arch. Consequently, this long, exteriorized guidewire permits easier device tracking to the desired position, as well as the ability to advance or retract the device in a controlled manner by holding the stent-graft delivery system and guidewire as a unit. With use of the video-assisted system, the ascending aorta could be visualized clearly, and the purse-string suture needed no particular technique. Formichi and Renier[10] have reported that the transseptal guidewire technique has the same concept, but this is considered simple only for well-trained physicians.[10] Our video-assisted sheath insertion is simple and needs no particular training. The guidewire control of our new pull-through technique is thought to be more accurate than that of transseptal technique.

Conclusion

For stent-grafting of aortic arch aneurysms, accurate deployment and placement are very important. In the present experimental study, our new pull-through technique from the ascending aorta to the femoral artery was very useful. Furthermore, the video-assisted sheath insertion to the ascending aorta was safe and simple. By our method, stent-grafting for the aortic arch aneurysms is expected to be more accurate and safer.

Acknowledgments

The authors gratefully acknowledge the technical and scientific assistance of Miyazaki Technology and Educational Center of Boston Scientific Japan Co, Ltd.

REFERENCES

1. Matsui O, Yoshikawa J, Sanada J, et al: Development and clinical application of flexible nitinol stent-graft for aortic aneurysms (abstract). Cardiovasc Intervent Radiol 22:(suppl 1):S69, 1999.
2. Sanada J, Matsui O, Terayama N, et al: Early clinical experience with a newly developed nitinol stent-graft for endovascular repair of aortic aneurysms (abstract). Cardiovasc Intervent Radiol 23(suppl 1): S144, 2000.
3. Matsuoka T, Kitagawa K, Tsuruoka S, et al: Two cases of traumatic aortic injury treated by emergent stent-graft placement (Japanese). Intervent Radiol 15:358-362, 2000.
4. Ishimaru S, Kawaguchi S, Koizumi N, et al: Preliminary report on prediction of spinal cord ischemia in endovascular stent graft repair of thoracic aortic aneurysm by retrievable stent graft. J Thorac Cardiovasc Surg 115:811-818, 1998.
5. Dake MD, Miller DC, Semba CP, et al: Transluminal placement of endovascular stent-grafts for the treatment of descending thoracic aortic aneurysms. N Engl J Med 331:1729-1734, 1994.
6. Criado FJ, Barnatan MF, Rizk Y, et al: Technical strategies to expand stent-graft applicability in the aortic arch and proximal descending thoracic aorta. J Endovasc Ther 9:II32-II38, 2002.
7. Sanada J, Matui O, Terayama N, et al: Clinical application of newly developed curved-type nitinol stent-graft for thoracic aortic aneurysms. J Endovasc Ther 10:20-28, 2003.
8. Kato N, Shimono T, Hirano T, et al: Aortic arch aneurysms: Treatment with extra-anatomical bypass and endovascular stent-grafting. Cardiovasc Intervent Radiol 25:419-422, 2002.
9. Dorros G, Dorros AM, Planton S, et al: Transseptal guidewire stabilization facilitates stent-graft deployment for persistent proximal ascending aortic dissection. J Endovasc Ther 7:506-512, 2000.
10. Formichi M, Renier JF: A laparoscopic approach to the abdominal aorta for thoracic stent-graft deployment: Evaluation in a porcine model. J Endovasc Ther 9:344-349, 2002.