A new vascular ring connector in surgery for aortic dissection

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Objective: To improve the surgical results of aortic dissection, we used a novel vascular ring connector for anastomosis.

Methods: The vascular ring connector is a titanic ring used as a stent in the vascular graft to achieve a quick, blood-sealed, and sutureless anastomosis. From November 2007 to December 2008, 19 consecutive patients (age range 36–77 years; 16 male and 3 female) with aortic dissection underwent open surgery. All patients received aortic reconstruction with vascular grafts (including 5 cases of arch replacement). The combined procedures were 5 Bentall and 4 coronary artery bypass graft operations.

Results: There were no significant blood leaks from the anastomotic sites. The time required for each anastomosis was 1 to 2 minutes. All patients were discharged uneventfully and are still doing well after a follow-up period of 1 to 12 months.

Conclusion: The vascular ring connector may improve the early surgical results of aortic dissection by reducing both the time for anastomosis and the risk of bleeding and may be an alternative technique for aortic reconstruction. Its usefulness in the routine treatment of aortic dissection warrants further evaluation.

Bleeding and complications related to prolonged pumping time are the major risks in open surgery for aortic dissection. The fragility of aortic tissue makes suturing of the vascular prosthesis to the aorta difficult. Minimization of the bleeding from the suture line at the site of anastomosis is the major challenge for such an operation. To reduce the bleeding from the suture line, the sutureless intraluminal graft was introduced.¹⁻³ The early intraluminal graft did not come into wide use because of unsatisfactory results attributed to its suboptimal structure. A new vascular ring connector (VRC) (VASORING, Sunwei Technology Co, Taipei, Taiwan) has been designed to improve the efficacy and safety of the graft.

MATERIALS AND METHODS

Between November 2007 and December 2008, after receiving approval from the hospital institutional review board and obtaining individual consent, 19 consecutive patients (16 male and 3 female) underwent surgery for aortic dissection. The patients' average age was 58.7 ± 10.5 years (range, 36–77 years). The involvements of dissection were Stanford type A in 11 patients and type B in 8 patients; dissection was acute in 12 patients

and chronic in 7 patients at the time of surgery. Complications included severe aortic regurgitation in 5 patients and coronary artery occlusive disease in 4 patients. The efficacy and safety of the VRC, used for connecting the vascular prosthesis and aorta, were evaluated during and after the surgical procedures.

DESCRIPTION OF THE VASCULAR RING CONNECTOR

The VRC is composed of biocompatible titanium alloy and has various sizes (diameter range, 12–30 mm). There are 2 grooves on the outer surface of the VRC: The narrow groove is for suture fixation between the VRC and the vascular prosthesis, and the wider groove is for ligature fixation between the VRC and the aorta. The device is inserted into a vascular prosthesis to form an intraluminal graft (Figures 1-3). Braided tape, tied around the overlapping region of the aorta and VRC, provides a sutureless anastomosis. The titanium alloy allows the VRC to be of a thin-wall design that allows a large inner diameter while maintaining adequate mechanical strength at the anastomotic sites.

VASCULAR RING CONNECTOR IMPLANTATION TECHNIQUE

Type B Aortic Dissection

Posterolateral thoracotomy and partial cardiopulmonary bypass (CPB) through the femoral artery and inferior vena cava are used for reconstruction of the descending thoracic aorta. After CPB is instituted, 2 nylon tapes are used to encircle the aorta at the planned sites of anastomosis. The aorta is crossclamped and incised longitudinally. The diameter of the true lumen of the proximal anastomosis is estimated, and the VRC with a corresponding size is selected. The VRC is attached to the vascular prosthesis by securing the edge of the graft against the narrow groove of the VRC with

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Abbreviations and Acronyms

CPB = cardiopulmonary bypass
VRC = vascular ring connector

nonabsorbable sutures (Figures 1 and 2). The ringed prosthesis is then inserted into the aorta, positioned at the planned proximal anastomotic site, and fixed to the aorta by tying tapes against the wider groove (Figures 3 and 4). A similar maneuver is used for the distal anastomosis.

Type A Aortic Dissection

In patients who require reconstruction of the ascending aorta or aortic arch, a median sternotomy is performed and CPB is instituted through the femoral artery and right atrium. The right subclavian artery is also cannulated to perfuse the brain during circulatory arrest. After CPB is instituted, the ascending aorta is crossclamped and incised longitudinally. Cardiac arrest is achieved by infusing cardioplegic solution into the coronary orifices. If the intimal tear is located at the ascending aorta, the maneuver is similar to that used for type B dissection. If the intimal tear is located at the aortic arch, the perfusion is stopped through the femoral artery, the distal aortic clamp is released, only the brain is perfused through the right subclavian artery, and the aortic arch is opened. We prefer to perform the distal anastomosis first, and after that, a balloon catheter (eg, Foley catheter) is inserted to occlude the distal aorta and reinstitute the CPB through the femoral artery. The island flap technique is used to implant the branches of aortic arch to the vascular prosthesis. In patients with intimal tears near the aortic valves, Bentall's operation, using the inclusion or exclusion technique, is performed before the distal anastomosis with the VRC. If there are multiple tears involving the aortic root and arch, the sequence of the procedures will be Bentall's operation, distal anastomosis using a separate intraluminal graft, island flap for the branches of the aortic arch, and graft-to-graft anastomosis.

RESULTS

A total of 32 VRCs were used for anastomosis between the aorta and the vascular prosthesis in the 19 patients. Five patients with an intimal tear located at the aortic arch received transverse arch replacement. Bentall's operations (4 inclusion methods and 1 exclusion method) were performed in another 5 patients with severe aortic regurgitation. Four patients received concomitant coronary artery bypass grafting because of associated coronary artery occlusive disease. All operations are considered to be technically difficult and risky if performed with the conventional suture technique.

EFFICACY

There was neither active bleeding at the anastomotic sites nor dislodgement of the VRC in any of the 19 cases when the

FIGURE 1. There are 2 grooves on the outer surface of the connector: The narrow groove is for the suture fixation between the connector and the vascular prosthesis, and the wider groove is for the ligature fixation between the connector and the aorta. The VRC is inserted into the graft to form a ringed prosthesis.

patients' blood pressure returned to normal. The time needed for each anastomosis was only 1 to 2 minutes.

SAFETY

No patients had neurologic or embolic complications, such as cerebral ischemia or distal embolism, throughout the course of this study. The mean amount of bleeding during the first 24 postoperative hours was 309 ± 202 mL. The average amount of blood transfusion during the hospitalization was 1.9 ± 1.1 units. No patient was returned to the operating room for a bleeding check. All except 2 patients had their endotracheal tubes removed within 24 hours postoperatively, with an average of 11.7 ± 7.5 hours. All patients were discharged with uneventful hospital courses. During the follow-up period of 1 to 12 months, all patients remained in excellent condition. Computed tomography scans of all patients, repeated at the end of this study, showed no abnormality of the anastomotic sites.

DISCUSSION

Anastomosis between the vascular prosthesis and the aorta is sometimes the most challenging part of the surgery

FIGURE 2. The vascular prosthesis is attached to the VRC by securing the edge of the vascular prosthesis against the narrow groove of the connector. A 2-0 nonabsorbable suture is used to pierce the graft circumferentially along the groove.

FIGURE 3. The ringed graft is inserted into the aorta, and the braided nylon tapes are tied against the wider groove of the VRC to achieve a sutureless anastomosis.

for aortic dissection. Blood leaking from the suture line may lead to uncontrollable bleeding and even death. To avoid tearing the fragile tissue during aortic anastomosis, various techniques, including double-mattress sutures with Teflon felt, biological glue, and gelatin resorcin formalin glue, are reported in the literature.⁴

The first sutureless intraluminal graft with a fixed ring at each end was introduced by USCI (CR Bard Inc, Covington, Ga), in 1975 and modified into an adjustable length with 1 sliding ring by Meadox (Oakland, NJ). The ring is made of plastic tube covering with Teflon cloth. Although the use of these ringed sutureless grafts remarkably reduces aortic crossclamping time, the surgical results vary from institute to institute. Some report good immediate and long-term results,¹⁻³ whereas others have been less satisfactory.⁵⁻⁷ We have been using the USCI and Meadox intraluminal grafts in many cases since their early introduction, but we have experienced 2 potential risks: (1) The surface of the plastic tube is smooth, and the lack of furrow makes the fixation of the ring to the aorta not completely secure. Dislodgement of

the ring from the anastomosis is a catastrophic disaster that may lead to immediate death or later development of pseudoaneurysm.⁷ (2) Because the vascular prosthesis is placed inside of the ring that is covered with a thick layer of cloth, its diameter is thus limited by the ring and pressure gradient over the anastomosis may occur after the surgery. The VAS-ORING VRC is designed to avoid the above-mentioned disadvantages: The furrow on the surface of the VRC holds the external fixation better, and the thin-walled titanic ring provides a larger internal diameter.

Some investigators may be concerned about tissue necrosis at the anastomosis, caused by compression from the ligature tapes around the aorta. In another unpublished study (2003), we implanted VRCs in the aorta of 11 adult pigs and removed the VRCs together with the aorta for examination 6 months later. We found that the intima underneath the ligature tapes was intact and could hardly be separated from the VRC because of the formation of fibrotic tissue. In our patients, the follow-up computed tomography scans showed no pseudoaneurysm formation, perhaps because the anastomosis is supported by a homogenous contact surface exerted by the tapes against the VRC, instead of a suture line containing multiple holes pierced by the needles. Although our early results in these patients are good, a longer follow-up time for observation is needed. In addition, to avoid damaging the intima, excessive force should not be used to tie the tapes during fixation of the VRC.

Thromboembolism is also a concern with the use of VRCs. In the same animal experiment mentioned above, there was no thrombosis in the inner surface of the rings at the end of the study. None of our patients showed clinical evidence of thromboembolism during the follow-up period of 1 to 12 months. The lack of thromboembolism may be due to the biocompatibility of the titanium material and its short length.

When using the conventional suturing technique, the site of anastomosis is sometimes close to the aortic clamp, making the suturing process difficult. With the use of VRCs, the time required for anastomosis is short. Thus, the aortic clamp may be temporarily released to allow the graft to pass into the anastomotic site for fixation with minimal risk of brain ischemia.

Endovascular stent grafts, commonly used for the treatment of abdominal aortic aneurysm, also have been used for the treatment of type B aortic dissection in selected patients until recently.⁸ Their use in patients with type A and even type B dissection, however, is still impossible.

The device will not allow for complete exclusion of the ascending aorta as part of a proximal hemiarch repair, as is performed in many institutions with experience in dissection.

CONCLUSIONS

The use of VRCs may improve the early surgical results of aortic dissection by reducing both the time for anastomosis and the risk of bleeding, and may be an alternative technique for aortic reconstruction. The routine usefulness of

FIGURE 4. Completed reconstruction of the descending aorta with 2 VRCs at each end of the vascular prosthesis in a patient with acute type B aortic dissection.

VRCs in the treatment of aortic dissection warrants further evaluation.

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