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Off-Pump Coronary Artery Surgery with the Use of Anastomotic Devices: An Additional Tool for the Challenging Patient

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ABSTRACT

Background. Avoidance of aortic side-clamping may decrease the risk of embolization to the brain and other organs during coronary revascularization. Herein we describe our preliminary experience with an anastomotic device for proximal anastomosis construction.

Methods. From October 2000 to June 2001, 18 selected patients undergoing beating heart surgery had an aorta-to-saphenous vein graft anastomosis performed with the St. Jude Medical Aortic connector.

Results. All anastomoses were successfully deployed. In two patients there was a minor anastomotic bleeding and in other two cases a kinking occurred due to a too short and a too long graft respectively. One patient, with graft occlusion on the fourteenth postoperative day, underwent successful percutaneous revascularization.

Conclusions. Our preliminary results indicate that the aortic anastomotic device is safe and effective and its use could be widened once long-term results are available.

INTRODUCTION

The population of patients undergoing coronary artery bypass grafting is evolving rapidly. Since the introduction and diffusion of interventional cardiology procedures, patients referred to surgery are older and sicker. With recent advances in myocardial protection and other surgical techniques, mortality and morbidity is today more related to the copathologies of the patients than to heart function and complexity of the surgical procedure [Mohan 1992]. Introduction of beating heart revascularization has further contributed to reduction of morbidity and mortality in high risk patients, avoiding the pathophysiology of cardiopulmonary bypass [Moshkovitz 1995]. Another step towards a better control of the perioperative risks is the avoidance of aortic manipulation, which is expected to reduce the neurological complications of coronary revascularization and contribute to limitation of invasiveness of surgery [Smith 1986, Pugley 1994].

Anastomotic devices have been introduced years ago in general surgery and are commonly preferred for their reproducible quality, easiness of use, and reliability. Newly introduced devices open the perspective of "automatic" anastomoses in coronary surgery [Shennib 2000, Calafiore 2001]. Standardization of the quality of the anastomoses may favorably affect short and long-term results and facilitate the overall procedure.

Herein we describe our preliminary experience with an anastomotic device designed for proximal anastomosis construction.

METHODS

Since October 2000, in 18 patients (all male, mean age 67 ± 12 yrs) undergoing beating heart coronary artery revascularization, one or two proximal anastomoses between the aorta and the saphenous vein were performed using the St. Jude Medical Aortic Connector™ (St. Jude Medical, St. Paul, MN) system. A total of 28 proximal anastomoses were done, with a mean of 1.55 ± 0.51 anastomoses per patient. Patients were selected among those with higher risk from aortic manipulation. Twelve patients (66%) had severely calcified aorta or diffuse atherosclerotic disease with increased risk of embolization related to side biting clamping. In two patients (11%), the device was used during reoperative surgery to limit the need for pericardial adhesions dissection. In four cases (23%), the device was utilized in the setting of severely depressed left ventricular function (EF < 30%). In this case the rationale was the avoidance of increased left ventricular afterload related to the aortic pressure gradient associated to side biting clamp.

The St. Jude Aortic Connector™ is available in three sizes: small (from 3.5 to 4.5 mm), medium (from 4.5 to 5.5 mm) and large (from 5.5 to 6.5 mm). The small size has been introduced into the market only recently. Before the availability of this size of Aortic Connector™, we had two cases where the device could not be used because of mismatch between the available connector and the vein graft dimensions. In both circumstances, the veins were too small, and a conventional anastomosis was performed (in one redo case with regular side biting clamp, following adhesions dissection of the ascending aorta; in the other case, the anastomosis was done on the proximal innominate artery). The small size

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connector was selected for 4 anastomoses, the medium size for 13 and the large one for the remaining 11 cases.

The deployment was done on the ascending aorta after completion of the anastomosis of the internal mammary artery on the left anterior descending artery in all but two cases where only venous grafts were used.

During deployment, aortic blood pressure was controlled by temporary occlusion of the inferior vena cava, to achieve a systolic blood pressure below 100 mm Hg.

Haemostasis was checked in all cases following the deployment.

Hemodynamic performance was assessed in each case, following the device deployment, by observing blood flow through the graft, before completion of the distal anastomosis.

RESULTS

The use of the device was successful in all cases. We did not observe any structural or mechanical failure of the mounting and of the deploying device.

The mean time of set-up and deployment was 9.9 ± 5.0 min per anastomosis, with a steep trend towards reduction of time with increasing experience. There were two cases of minor bleeding from the anastomotic site which were treated with a purse string to reduce the stress over the connector. There were two cases of kinking of the graft. In one case, it was due to a too short graft to the obtuse marginal artery with the kinking site close to the proximal anastomosis. Placing a purse string on the antero-lateral aspect of the pulmonary trunk solved the kinking. By doing so, the pulmonary trunk is displaced medially and the vein gets to the target coronary vessel through a straighter path. In the other case, the vein was too long and was oriented in an S shape by tacking it on the epicardial surface with artificial glue. Placing a collagen sponge-made ball below the vein, close to the proximal anastomosis, prevented the kinking.

One patient experienced recurrent angina and cardiac arrest on the fourteenth post-operative day. He was submitted to angiography, which showed total occlusion of the vein graft (an aorta to marginal artery graft) and was successfully treated by percutaneous coronary angioplasty of the native vessel.

DISCUSSION

The technical aspects:

Mounting

The St. Jude Medical Aortic Connector™ is a nitinol device, which connects vein grafts to the wall of the proximal ascending aorta. The set-up, mounting and deploying of the device is quite intuitive, and the whole process can be completed within a short time (between 5 and 10 minutes), following a straightforward and rapid learning curve. However, the mounting of the vein over the deployment device is the critical step for the quality of the connection. Mounting should be as accurate as with standard suturing techniques to reach short and long term optimal results. Inaccurate mounting could end up with anastomotic leaks or with a stenotic connection.

Control of bleeding

Bleeding, which in our experience occurred in two cases, is usually related to mismatch between the size of the graft and the width of the aortic opening. It might be postulated that, in these cases, following the use of the cutter, the hole made in the aortic wall, dilates more than expected for some reason (compression and dilation with the finger used to control the bleeding from the anastomotic site, hypertension and overstretching of the hole borders, etc.), and the connector-graft system is not able to cover the full area of the aortic hole. In this case, bleeding can be effectively controlled with a purse string constructed around the anastomosis to reduce the stress on the connection and the width of the aortic hole. In our experience, we did not observe any bleeding related to partial or total detachment of the graft from the connector. In this case, it is probably advisable to proceed with a conventional suturing anastomosis using a side-biting clamp. When this is not applicable, as in case of heavily calcified aorta, a closing device could be very useful, but it is not yet available.

Sequence of anastomosis

With the currently available device, the proximal anastomosis should be completed before the distal one. This is a limitation for those surgeons who are used to perform the distal anastomoses before the proximal ones. However, many surgeons routinely do the proximal anastomosis first, especially in beating heart revascularization surgery, to restore coronary flow, soon after completion of the coronary anastomosis.

Inclination of anastomosis and risk of kinking

The design of the connector implies a 90° inclination of the vein with respect to the proximal ascending aorta. To avoid kinking, the anastomosis should be placed in the convexity (for right sided grafts) or in the concavity (for left sided grafts) of the ascending aorta to favor a straight path of the graft towards the distal target vessel. The anterior surface of the aorta should be avoided, because of the risk of kinking and the possibility of compression by the mediastinal tissue. The risk of kinking is higher when the length of the vein graft is inadequate. In case it is too long, the vein can be accommodated on the epicardial surface of the heart in order to force it to make smooth curves. When too short, more room for the graft can be obtained for left sided grafts by placing a large purse string on the pulmonary artery trunk. When these maneuvers are ineffective, kinking can be corrected by placing a collagen gauze under the vein to straighten the graft.

The quality of the anastomosis

Using anastomotic devices, the quality of the anastomosis is unrelated to a surgeon's skill. Proximal placement of the graft allows testing of the graft flow soon after each deployment. In our experience, flow through the graft was excellent in all cases. The quality of the anastomosis is related to the correct completion of all the mounting and deployment steps of the device. We found it useful to control aortic mean and systolic blood pressure during the deployment. Preload

reduction by inferior vena cava temporary occlusion has been a useful solution for fast-response blood pressure control during beating heart surgery.

Indications and future applications

In the absence of long-term results, we decided to use the anastomotic device in selected patients undergoing off-pump beating heart surgery: namely, in the presence of severely calcified aorta, in reoperative surgery, and in case of severely depressed left ventricular function. We believe that the anastomotic devices are less useful (probably meaningless) when conventional on-pump revascularization with cardioplegic arrest is done. In off-pump surgery, conversely, the devices facilitate and expedite the proximal anastomosis procedure that can be paradoxically more cumbersome than the distal one in many occasions. The drawbacks of the procedure include the cost (around $300-$400 USD per device), and the lack of long-term clinical and angiographic follow-up. Once safety, efficacy and durability of the devices are demonstrated, their application could be widened. A systematic use of automated proximal anastomosis devices could decrease the neurocognitive effects of coronary artery revascularization.

If long-term results confirm our preliminary perception, anastomotic devices for proximal anastomosis should be considered a major improvement in coronary artery surgery, second only to the impact of the stabilizers for beating heart procedures.

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