

# Early Results of Aortic Connector System for Proximal Anastomoses of the Saphenous Vein Graft

Kazuhiko Nishizaki, MD and Toshio Seki, MD

**Purpose:** Our objective is to clarify the technical points in using the symmetry aortic connector system (ACS) compared with hand-sewing from clinical and angiographic results of the patients who underwent off-pump coronary artery bypass grafting (CABG).

**Methods:** Among 84 patients who underwent CABG from January 2002 to August 2003, 36 off-pump CABGs were performed using at least one saphenous vein graft (SVG). Thirty proximal anastomoses of 17 patients were performed by ACS, and 30 proximal anastomoses of 19 patients were performed by hand-sewing under aortic side-clamping. Angiogram of the coronary arteries and grafts was carried out 18 days after the operation.

**Results:** Comparing the preoperative characteristics and intraoperative characteristics between the ACS group and hand-sewing group, revealed no significant factors at all. Postoperative angiography of coronary arteries and grafts revealed that the four SVGs with ACS were occluded probably because of kinking near the proximal anastomosis site. On the other hand, all SVGs anastomosed by hand-sewing were patent.

**Conclusion:** ACS is very useful with easy handling during off-pump CABG, but it has potential limitations. In our limited experience, we have to mind the graft length as well as the position of proximal anastomosis so that the graft does not kink. (*Ann Thorac Cardiovasc Surg* 2005; 11: 98–103)

**Key words:** off-pump CABG, symmetry aortic connector, saphenous vein graft

## Introduction

In recent years, patients for coronary artery bypass grafting (CABG) have been older and have had many diffuse, serious coronary stenoses. The off-pump CABG technique has become widespread because of its reduction of the serious complication of perioperative stroke.<sup>1-4)</sup> *In-situ* arterial grafts have excellent patency in the long term,<sup>5)</sup> while CABG using only arterial grafts without manipulation of the ascending aorta is ideal — even in elderly cases,<sup>6,7)</sup> Occasionally, however, saphenous vein grafts (SVG) have been indispensable for complete revasculari-

zation. Recently, the sutureless aortic connector system (ACS, St. Jude Medical, Inc., St Paul, MN) was developed for creating anastomoses between the SVG and the ascending aorta without side-clamping.<sup>8-10)</sup> We examined consecutive patients who had off-pump CABG over 7 months. Here, we report the angiographic and clinical results, and clarify the important technical points in using ACS, compared with ACS and hand-sewing under aortic side-clamping.

## Methods

We investigated the clinical and angiographic outcomes of patients who underwent off-pump CABG. In our hospital, 84 patients had CABG — 47 off-pump and 37 with extracorporeal circulation — from January 2002 to August 2003. ACS had come into use in February, 2003; before then proximal anastomosis of SVG was performed under partial clamping of the ascending aorta, and after

*From Department of the Cardiovascular Surgery, Nara Prefectural Mimuro Hospital, Nara, Japan*

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Address reprint requests to Kazuhiko Nishizaki, MD: Department of the Cardiovascular Surgery, Nara Prefectural Mimuro Hospital, 1-14-16 Mimuro, Sango-cho, Ikoma-gun, Nara 636-0802, Japan.

**Table 1. Preoperative characteristics of the patients**

	ACS (n=18)	Hand-sewing (n=17)	P value
Gender M:F	12:6	7:10	0.20
Age	68.0±8.0	68.6±5.6	0.80
Coronary Risks			
Diabetes Mellitus	10 (55.6%)	15 (83.3%)	0.10
Hypertension	9 (50.0%)	6 (33.3%)	0.93
Hyperlipidemia	5 (27.8%)	5 (27.8%)	0.48
Smoking	7 (38.9%)	6 (33.3%)	0.85
Coronary Disease			
LMTD	7	6	0.83
TVD*:DVD*:SVD	14:3:1	10:6:1	0.26
Old myocardial infarction	8 (44.4 %)	12 (70.6 %)	0.19
Hemodialysis	3 (16.7%)	5 (27.8%)	0.38
Left ventricle ejection fraction (%)	50.2±23.4	51.2±20.0	0.86

ACS: aortic connector system, LMTD: left main trunk disease, TVD: triple vessel disease, DVD: double vessel disease, SVD: single vessel disease, \*including the number of LMTD

**Table 2. Intraoperative and postoperative data**

	ACS (n=18)	Hand-sewing (n=17)	P value
Operative time (min.)	299±29	296±71	0.30
Bleeding (ml)	162.9±95.6	207.5±142.7	0.49
The number of total bypass grafts	2.9±0.7	2.8±0.80	0.70
The total number of the proximal anastomosis	30	30	
Flow of the SVG (ml/min.)	39.6±32.1	40.4±29.2	0.93
The number of graft occlusions	4	0	
Diameter of coronary artery at anastomosis site (mm)	1.53±0.37	1.89±1.80	0.29

ACS: aortic connector system, SVG: saphenous vein graft

February 2003 we used this device consecutively in all patients who had off-pump CABG using SVG. In 11 of 47 off-pump CABG patients, total revascularization was performed using *In-situ* arterial grafts. The SVG was used in combination with *In-situ* arterial grafts in 36 patients. Thirty proximal anastomoses in 17 patients were performed using the ACS device, and 30 proximal anastomoses in 19 patients were performed by hand-sewing with 5-0 polypropylene under aortic side-clamping.

The intraoperative blood flow in the proximal portion of the SVG was routinely measured using a 2.5 MHz Doppler flow probe (Butterfly Flowmeter, Sedi-Stim Inc., Oslo, Norway). After the operation aspirin and warfarin was administered to all patients, with the international normalized ratio (INR) controlled between 1.8 and 2.2, in order to avoid thrombosis around the connector and in the SVG.

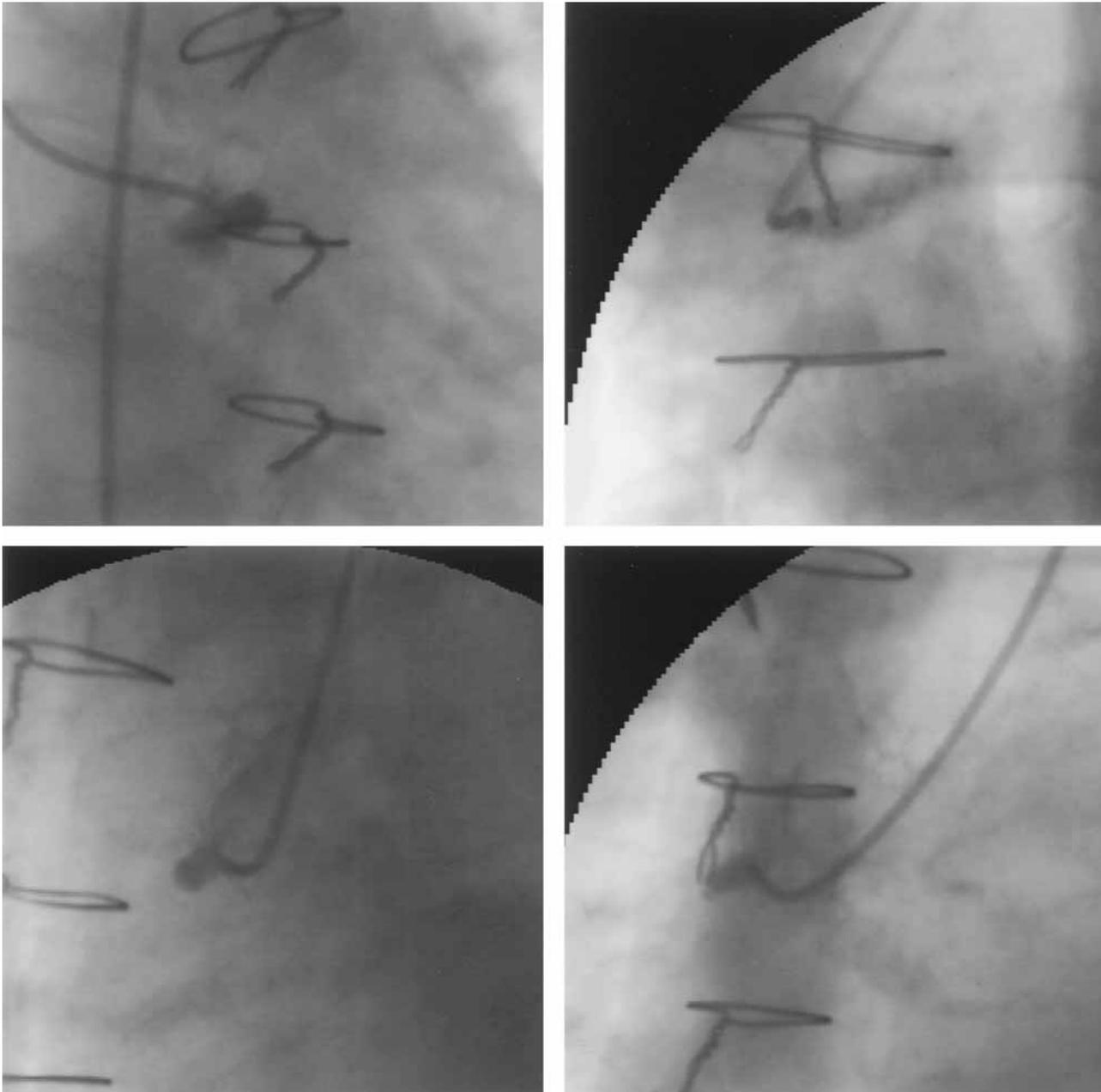
Sixteen days after the operation, stress-rest 201-Tl single photon emission computed tomography (SPECT) was performed for the patients in the aortic connector group. Stress exercise was loaded according to the Bruce

protocol using an ergometer bicycle. Angiography of the coronary arteries and grafts was performed 18 days after the operation. We compared and assessed clinical factors and angiographic outcomes between the connector group and the hand-sewing group.

Categorical variables of preoperative patient characteristics were compared using a Chi-square test and continuous data were compared using the Wilcoxon rank test. All tests were two-sided and *p* values of 0.05 or less were considered significant.

## Results

The comparison of preoperative characteristics between the ACS group and hand-sewing group is shown in Table 1. There were no significant factors differentiating the two groups. Operative patient characteristics are presented in Table 2. Except for simultaneous abdominal aorta replacement, operative time and amount of bleeding were not significant. There were no failures to create anasto-



**Fig. 1.** Postoperative angiogram of 4 occluded SVGs anastomosed by the aortic connector system: in each of the 4 grafts the occlusion was situated about 1 cm from the proximal anastomosis site. SVG in A and B are the grafts of the right coronary artery (RCA) and SVG in C and D are the grafts of the obtuse marginal branch.

A	B
C	D

moses using the ACS. The graft flow was not significantly different between the two groups. Stroke did not occur in any patient and the postoperative course was uneventful in both groups.

Postoperative angiography of coronary arteries and grafts revealed that 4 SVGs anastomosed by ACS were occluded. On the other hand, all SVGs anastomosed by

hand-sewing were patent. In each of the 4 grafts the occlusion was situated about 1 cm from the proximal anastomosis site (Fig. 1). Two of the four occluded SVGs were grafts to the left circumflex coronary artery (RCA) with two aortic connectors (gray size: 4.5 to 5.0 mm) and the others were to the right coronary artery (RCA) with two aortic connectors (green size: 5.0 to 5.5 mm). The differ-

**Table 3. Bypass grafting with SVG using ACS**

	Patent (n=26)	Occlusion (n=4)	P value
Size of ACS			
Gray (4.5 to 5.0 mm)	12	2	
Green (5.0 to 5.5 mm)	10	2	
Blue (5.5 to 6.0 mm)	4	0	
Flow in SVG (ml/min.)	45.36±40.0	20.0 ± 7.7	0.13
Diameter of coronary artery at anastomosis site (mm)	1.58±0.37	1.38 ± 0.25	0.38

ACS: aortic connector system; SVG: saphenous vein graft

ence in graft flow between patent grafts and occluded grafts using the ACS was not significant, but the graft flow in occluded grafts was lower than that in patent graft, as shown in Table 3. The relationships between graft occlusion and connector size are not clear in our results. Four patients with occluded SVGs were asymptomatic on loading exercise, but stress-rest 201-Tl SPECT revealed ischemia in the territory of the occluded graft. A week after the postoperative angiography, the stenosis site of the native coronary artery was revascularized by percutaneous catheter intervention in a patient.

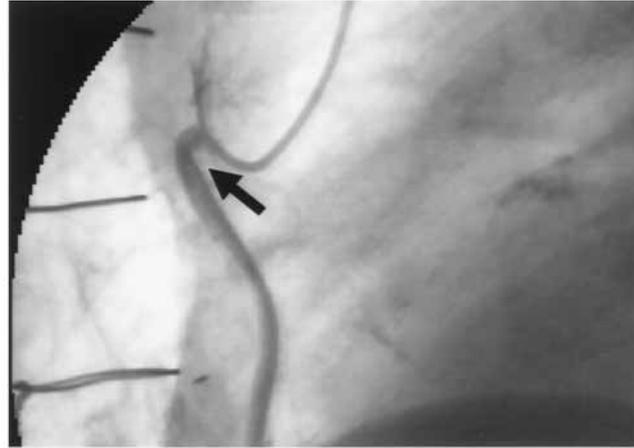
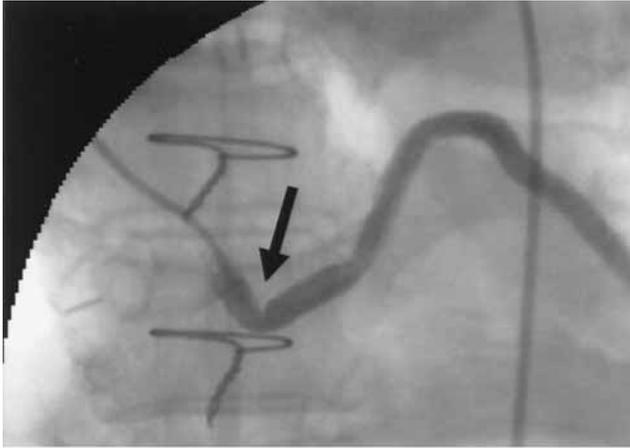
Between ten and sixteen months after the CABG using ACS, all patients had a complete clinical follow-up; there was no recurrence of angina.

## Discussion

When we create anastomoses between the SVG and the ascending aorta using off-pump CABG we usually have to partially clamp the ascending aorta. These manipulations occasionally cause embolization from aortic wall debris. The ACS is attractive for use in the off-pump procedure because the anastomoses can be carried out without side-biting of the aorta; this achieves blood pressure stability and avoids major aortic manipulation, therefore minimizing the risk of embolism. The presence of atheromatous plaque in the ascending aorta or aortic arch that may be mobilized during manipulation is the most important factor for perioperative neurological morbidity.<sup>11)</sup> Additionally, if the ascending aorta has severe and wide calcification (resembling porcelain), precluding side-clamping, it is possible to anastomose the SVG to a limited region of the ascending aortic wall — the island of least arteriosclerosis.<sup>12)</sup>

The ACS device is very useful but has potential limitations. Firstly, this connector is made of nickel-titanium alloy and there has been a report of an SVG that was occluded by thrombus at the connector site.<sup>13)</sup> To prevent

such a complication, aspirin and warfarin was administered to all patients after CABG. Secondly, the SVG anastomosed using this connector takes off at a 90° angle from the aorta. Such an SVG is easy to kink in the neighborhood of the aorta, which is the reason for the difficulty in the positioning of the SVG. In our first 2 patients, the SVG to the obtuse marginal branch was occluded about 1 cm from the proximal anastomosis site. By reviewing the angiogram of the SVG, we think that these grafts were implanted at the anterior wall of the ascending aorta, which is the major reason for graft kinking (Fig. 2A). For the proximal anastomosis site of the SVG to the left circumflex system, it is desirable to anastomose to a more lateral position, more nearly adjacent to the pulmonary artery.<sup>14)</sup> Since we have become mindful of this fact, we have experienced no occlusions of the SVG to the left circumflex system. On the other hand, in two patients, although we used a larger size of ACS, green size (5.0 to 5.5 mm), the SVG to the RCA was also occluded — probably by kinking of the graft. We considered that an SVG to the RCA would be more adjacent to the right atrium; but, after the chest wall is closed, pleural compression could cause the kinking of the SVG. After the first experience of kinking of the SVG to the RCA, we attempted to adhere the graft to the right atrium with fibrin glue, to prevent kinking and twisting. However, the SVG of the other patient (with good graft flow) was probably occluded by kinking. In this case, the SVG might have been slightly too long. The grafts that are too long are at risk of kinking because of exiting at a 90° angle from the aorta (Fig. 2B). On the other hand, grafts that are too short may present even more difficulties and overstretching of a short graft might cause immediate occlusion at the anastomotic site. We think that appropriate positioning is the situation of gently stretching the graft without making it too short (Fig. 2C). However, since this positioning may cause narrowing or stenosis of the graft, we think that the larger ACS is better. We should be aware of the differences be-



A	B
C	

**Fig. 2.** Postoperative angiogram: (A) the saphenous vein graft (SVG) anastomosed on obtuse marginal branch, approximately 1 cm from its connection with aortic wall, is kinked with critical stenosis (black arrow). Probably the SVG connected to the anterior wall of the aorta was kinked when the patient's chest was closed. (B) The SVG anastomosed on the right coronary artery (RCA), approximately 1 cm from its connection with the aortic wall, is kinked although it doesn't have stenosis but there is a risk of stenosis or occlusion because the length of the SVG was slightly too long. (C) The SVG anastomosed on the RCA is well patient. We recommend the positioning and graft length such as this angiogram; proper positioning and graft length is the situation of gently stretching the SVG without making it too short.

tween a graft to the RCA and a graft to the left circumflex coronary artery. If the length of the graft to the left circumflex coronary artery is only slightly too long, and if the position of the proximal anastomosis is appropriate, there will be little difficulty. But, in grafting to the RCA, one must be careful that the graft length is sufficient and that the position of the proximal anastomosis is appropriate. If a new device that makes side-to-side anastomosis is developed, we believe that adjustment of the graft length will be simplified.

Notably, there are no previous reports on the relationship between graft occlusion and connector size. Use of a size smaller than the SVG diameter could be expected to cause graft stenosis or occlusion. The results for our cases did not clarify this supposition. However, we think the smaller ACS probably influences kinking or narrowing which can cause occlusion of the SVG hence we rarely use the smaller ACS (gray size, 4.5 to 5.0 mm).

In our study, there are several limitations. This study was a retrospective and nonrandomized observation study. The backgrounds of the two groups of each comparison were not equivalent and the number of each group was small. However, it is important to note our suggestions and points that we are aware of in the light of our experience. Overall more experience is necessary.

The symmetry ACS is very useful and provides easy handling of off-pump CABG. However, some SVGs using ACS became occluded in the early postoperative period regardless of a graft flow or a size of the ACS. With the aim of preventing such occlusions, we have investigated the optimal site for anastomosis to the ascending aorta and the most efficacious root and length of the SVG to the coronary artery — especially to the RCA. Looking beyond this study, we believe it is important to examine long-term efficiency and durability, with regard to neointimal hyperplasia, associated with the ACS.

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