

Kinking of Internal Thoracic Artery Graft without Symptoms: Should It Be Revised?

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ABSTRACT

Background. Surgery or intervention therapy has been performed to correct kinks of internal thoracic artery (ITA) grafts. The aim of this study was to evaluate the natural course of the ITA graft kink and to clarify whether surgery or intervention therapy should be performed in asymptomatic patients during the early postoperative period.

Methods. We investigated the early and follow-up angiographic results of ITA graft kinks in 7 consecutive patients who did not undergo surgical or interventional correction. The graft diameter and percentage of diameter stenosis at the kink site were compared between the early postoperative angiography and the follow-up angiography.

Results. Early postoperative angiography revealed that the diameter stenosis at the kink site was $60.1\% \pm 6.9\%$ (range, 51 to 69) and the diameter at the kink site was 0.92 ± 0.20 mm (range, 0.63% to 1.25%). The ITA kinks disappeared in all the patients and the diameter of the ITA graft adjacent to the kink was not significantly changed on the follow-up angiography. No luminal irregularity or indentation was shown. All the patients had been free from cardiac events until the follow-up angiography.

Conclusion. Kinking of an ITA graft that's seen on the early postoperative angiography might improve without surgery or intervention. The natural course of ITA graft kinks should be considered when detecting these kinks on the early postoperative angiography when the patient is asymptomatic.

INTRODUCTION

The internal thoracic artery (ITA) has been widely used for coronary artery bypass surgery because its long-term patency is superior to that of other conduits and grafts.

Atherosclerosis is rarely found in the ITA and many clinical studies have demonstrated improved long-term survival and fewer cardiac events for patient receiving ITA grafts [Lytle 1985, 2001; Loop 1986]. However, there are scant reports about kinked ITA grafts and the interventional or surgical correction that has been performed in that situation [Brenot 1988; Kollar 1996; Goldstein 1998; Rerkpattanapipat 1999; Cetindag 2003]. Furthermore, the natural course of a kinked ITA graft has not been well established. The purpose of this study is to evaluate the natural course of a kinked ITA graft and to determine whether surgical or interventional therapy should be performed on a kinked ITA graft that is without symptoms.

MATERIALS AND METHODS

The Institutional Review Board of Samsung Medical Center approved this study on September 22, 2006. From August 2004 to March 2006, 682 patients underwent coronary artery bypass surgery with ITA grafts at Samsung Medical Center; 127 patients underwent postoperative angiography before discharge. The early postoperative angiography was performed for the patients who accepted the procedure after physician's recommendation. We studied 7 consecutive patients whose angiographies revealed internal thoracic artery kinks, but they did not undergo any surgery or interventional therapy because they did not have any clinical symptoms. The surgeon (Y.T. Lee) who performed all the operations decided not to correct the kinks because the patients were asymptomatic. The mean age of patients was 54.0 ± 10.6 years (range, 39 to 69 years; 6 [86%] were men). Early postoperative angiography was performed 4.6 ± 1.3 days (range, 3 to 7 days) after surgery, and follow-up angiography was performed 7.7 ± 5.6 months (range, 2 to 19 months) after surgery. Follow-up angiography was performed for the follow-up study, and the all patients were without symptoms. None of the patients were administrated an intravenous or catheter infusion of vasodilator drugs during the early and follow-up angiographic procedures.

All the patients underwent off-pump coronary artery bypass grafting for the first operation. Routine full sternotomy was performed for 6 patients and lower partial sternotomy was performed for 1 patient. The ITA was harvested along the full

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length from the sixth intercostal space to the first rib with a skeletonizing technique. Sharp dissection was performed with scissors and the branches were cut after clipping. Electrocautery was avoided as far as possible. The bilateral ITAs were harvested in 6 patients. The left ITA (LITA) was grafted to the left anterior descending artery (LAD) as an in situ graft in all patients and the right ITA (RITA) was grafted as a free graft in 6 patients. Y-grafts were constructed near the third branch of the LITA with the RITA or the distal segment of the LITA with using an 8-0 polypropylene continuous suture technique in 5 patients (Table). The routine sequence of grafting in our hospital is as follows. We perform the Y-anastomosis first, and then we construct the LITA-LAD anastomosis. After the LITA-LAD anastomosis, diagonal branches, obtuse marginal branches and posterior descending arteries were grafted with the RITA or the right gastroepiploic artery with a 8-0 polypropylene continuous suture technique. After completion of bypass, the graft flow was measured with Transonic flow-QC meter (HT 313; Transonic Systems, Ithaca, NY, USA).

ANGIOGRAPHIC ANALYSIS OF THE ITA GRAFT

The ITA graft was examined on multiple projections. Quantitative angiographic analysis was performed with an

automated edge-detection algorithm (off-line Xcelera; Philips, Amsterdam, Netherlands). The diameter of a 5 F catheter at the LITA ostium was used as the calibration standard. The diameter of the ITA graft and the percentage of diameter stenosis at the site of the kink were assessed by means of quantitative angiography. Two segments that were 1.5 to 2 cm in length proximal and distal to the ITA kink, respectively, were chosen for measuring the diameter of the ITA graft. The percentage of diameter stenosis was calculated on the most stenotic view of the early postoperative angiography.

Statistical Analysis

Values are expressed as means $\pm$ standard deviation. Differences in the parameters between the early postoperative and follow-up angiography were determined by performing paired *t* test analysis.

RESULTS

The intraoperative and postoperative courses of all the patients were uneventful. The flow curve pattern and the mean graft flow measured with the flow meter during operation were acceptable in all patients. The mean duration of the intubation time was 10.6 ± 6.9 hours (range, 3 to 23 hours) after surgery and the mean length of the intensive care unit stay was 1.4 ± 0.5 days (range, 1 to 2 days). Three patients were infused low-dose dopamine, and the other 4 patients were not infused with any inotropics. No patient developed chest pain or ischemic changes on electrocardiography. The patients were discharged 5.9 ± 2.3 days after surgery (range, 3 to 10 days) without any complication.

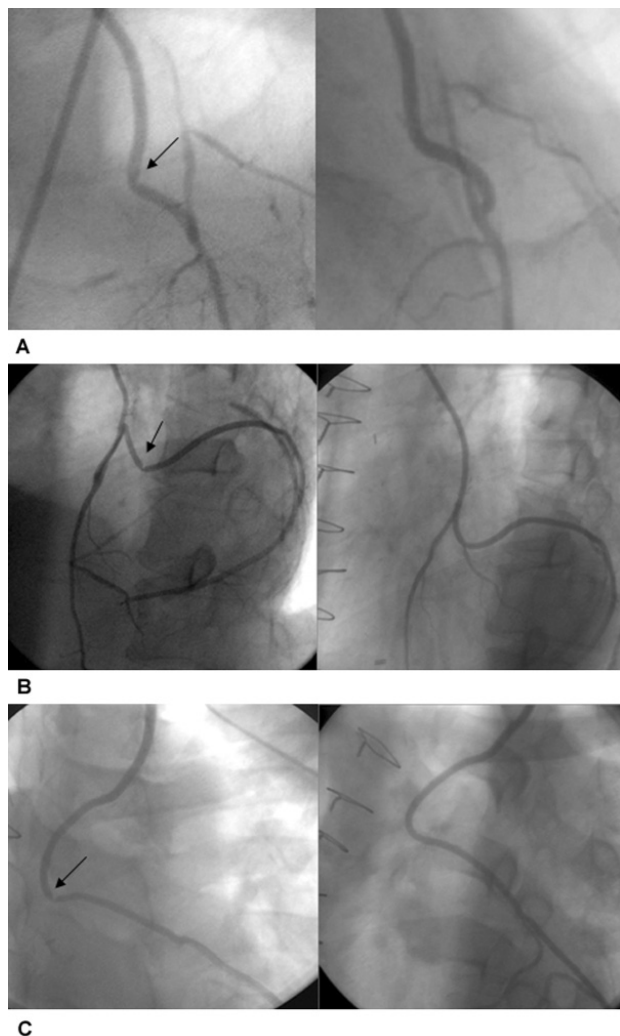
The early postoperative angiography revealed that the diameter at the stenosis was $60.1\% \pm 6.9\%$ (range, 51% to 69%) and the diameter at the kink site was 0.92 ± 0.20 mm (range, 0.63 to 1.25 mm). The locations of kinks was at the proximal LITA before the Y-anastomosis in 4 patients, the distal LITA before the LITA-to-LAD anastomosis in 2 patients who did not have a Y-graft performed, and just distal to the site of the side-to-side anastomosis between the RITA and the diagonal branch in 1 patient. Two ITA kink sites were found in 1 patient, and one ITA kink site was found in the other 6 patients (Table). All the anastomosis sites were patent. Graft-dependent blood flow to the target coronary artery was shown in 6 patients. Reversal of flow in the LITA segment between the Y-graft anastomosis and the LAD anastomosis was shown in 1 patient who's LAD was shown to have 50% stenosis.

All the patients were asymptomatic during the follow-up period. Follow-up angiography was performed in all patients to evaluate the changes of the ITA kinks. All the anastomosis sites were patent and any "string" sign of the ITA grafts was not detected in all the patients. The ITA kinks disappeared in all patients on follow-up angiography. No luminal irregularity or indentation was shown (Figure). In the patient with reversed flow in the LITA segment at early angiography, the reversed flow was still observed in that segment on follow-up angiography. The diameters of the proximal ITA grafts to the kinks on the early postoperative angiography and on the follow-up angiography were 2.25 ± 0.22 mm (range, 1.91 to 2.63 mm)

Profile of the Patients with Early Angiographic Findings*

	Age, y/Sex	Operation	Site of ITA Kink	Percent of Diameter Stenosis
1	F/58	LITA-LAD, LITA (mini Y-graft from in-situ LITA)-D, RITA (from aorta)-OM, RGEA-PDA	Proximal site to Y-graft	51%
2	M/53	LITA-LAD	Distal LITA	60%
3	M/61	LITA-LAD, RITA (Y-graft from in-situ LITA)-D-OM-PDA	Distal site of RITA-D anastomosis	56%
4	M/48	LITA-LAD, RITA (Y-graft from in-situ LITA)-D-OM	Proximal site to Y-graft	69%
5	M/50	LITA-LAD, RITA (Y-graft from in-situ LITA)-RI-OM- OM, RGEA-PDA	Proximal site to Y-graft (x2)	54%, 58%
6	M/69	LITA-LAD, RITA (from aorta)-OM-OM, RGEA-PDA	Distal LITA	66%
7	M/39	LITA-LAD, RITA (Y-graft from in-situ LITA)-OM-PDA	Proximal site to Y-graft	66%

*ITA indicates internal thoracic artery; LITA, left internal thoracic artery; LAD, left anterior descending artery; D, diagonal branch; RITA, right internal thoracic artery; OM, obtuse marginal branch; RI, ramus intermedius; RGEA, right gastroepiploic artery; PDA, posterior descending artery.



Early postoperative and follow-up angiographic findings of the internal thoracic artery (ITA) kink. Early postoperative angiography showed the kink at the distal left ITA (LITA) before the LITA to left anterior descending artery anastomosis (A), at the site just distal to the side-to-side anastomosis between the right ITA (RITA) and the diagonal branch and at the proximal LITA before the Y-anastomosis with the RITA (C). No luminal irregularity or indentation was shown on the follow-up angiography. Arrows indicated the site of ITA kinks.

and 2.33 ± 0.21 mm (range, 2.03 to 2.68 mm), respectively. The diameters of the distal ITA grafts to the kinks on the early postoperative angiography and the follow-up angiography were 2.20 ± 0.20 mm (range, 1.78 to 2.36 mm) and 2.27 ± 0.24 mm (range, 2.07 to 2.72 mm). The diameters of the segments proximal and distal to the kinks were not significantly changed ($P = .128$ and $P = .612$, respectively).

DISCUSSION

The ITA is the graft of choice for coronary artery bypass surgery because it has better long-term patency, a longer ischemic event-free period and a better survival rate than

do the saphenous vein grafts [Lytle 1985, 2001; Loop 1986]. Kinks in the ITA grafts have been reported in a few cases in the medical literature. All the cases were treated by surgery or intervention, except for one case. Imamaki et al [2005] reported that a kink in an ITA graft one year after surgery appeared to be the same as that at the postoperative 10th day. To the best of our knowledge, regression of a kink in the ITA graft with time has not previously been reported.

Surgical technique may play a major role for treating kinks in the ITA graft. An excess length of the ITA may cause a vascular loop and a resultant kink. With the increasing use of bilateral ITA grafts, the skeletonizing harvesting technique has been reported to reduce the incidence of wound infection [Ridderstolpe 2001; Peterson 2003]. However, it was suggested that a skeletonized ITA graft is more apt to kink than a pedicled ITA graft [Imamaki 2005]. Because of the veins and fascia around an ITA, a pedicled ITA graft can run in a gentle curve without making a kink. During off-pump coronary artery bypass grafting, a LITA-to-LAD anastomosis is performed first in the majority of cases. We like to have a slightly redundant length of the LITA to avoid tension on a LITA-to-LAD anastomosis during performing other anastomosis, and especially for the obtuse marginal branch anastomosis. We did not find any kinks in all the patients during operating. The ITA grafts were in a harmonious curve in all the patients. There is possibility that the ITA graft loses this harmonious curve because of the cardiac and respiratory movements after the chest cage is closed. To prevent kinking of the ITA it has been suggested that fibrin glue should be used to paste the ITA graft so as to allow it to run and stay in a gentle curve [Imamaki 2005].

Focal spasm in the ITA graft can cause defects on the postoperative angiogram. In the case of spasm, the luminal narrowing could occur on both sides of the curvature and the appearance does not look like indentation. On the early postoperative angiogram in this study, the defects were on the less curvature and the line of the greater curvature was smooth in addition to their narrowness. So we considered the defects to be kinks.

There have been reported cases of ITA kinking with the symptoms being corrected via surgery or catheter intervention [Brenot 1988; Kollar 1996; Rerkpattanapipat 1999; Cetindag 2003]. Even with an ITA kink, it was reported that the myocardial scintigrams revealed no sign of myocardial ischemia in the asymptomatic patients [Imamaki 2005]. Considering that the graft is dependent on blood flow to the target coronary artery, and this was shown in all our patients except one whose LAD stenosis was not tight and any chest pain or ischemic electrocardiography change did not develop in the postoperative period, it is not always necessary to correct an ITA kink. Surgery can cause injury to other graphs during sternal re-entry, and interventional therapy can cause dissection or restenosis in the graft.

It was reported that the ITA stenosis observed at the anastomotic site during the early postoperative angiography regressed without interventional therapy [Izumi 2005]. The authors of that paper suggested the possibility that the ITA graft stenosis observed on the early postoperative angiogra-

phy is not rigid and it is expandable, and the degree of the stenosis might change depending on the ITA graft flow. Regression of the ITA graft kink could be the possible mechanism for regression of ITA graft stenosis, although we did not evaluate the ITA graft flow using a Doppler flow wire in the present study. The degree of the diameter stenosis in the ITA graft kink on the early angiography showed no relationship with regression of the ITA graft kink and the manifestation of clinical symptoms because all the ITA graft kinks regressed and all the patients were asymptomatic in this study. The authors of a recent report on an ITA kink with symptoms didn't mention the degree of the diameter stenosis in the ITA kink [Brenot 1988; Rerkpattanapipat 1999; Cetindag 2003].

In conclusion, the observed kinking of an ITA graft on the early postoperative angiography might improve without surgery or intervention. The natural course of a kink of an ITA graft should be considered when detecting such a kink on the early postoperative angiography when the patient is asymptomatic.

Study Limitations

The early postoperative angiography was performed in 18.5% patients who underwent coronary artery bypass surgery with ITA grafts. Most of them were asymptomatic. Two patient complained of chest pain but no kink was revealed in those patients. We did not know exact incidence of ITA graft kinks in our hospital and could not exclude the possibility that ITA graft kinks remain unchanged without symptom because of the low rate of performing the early postoperative angiogram.

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