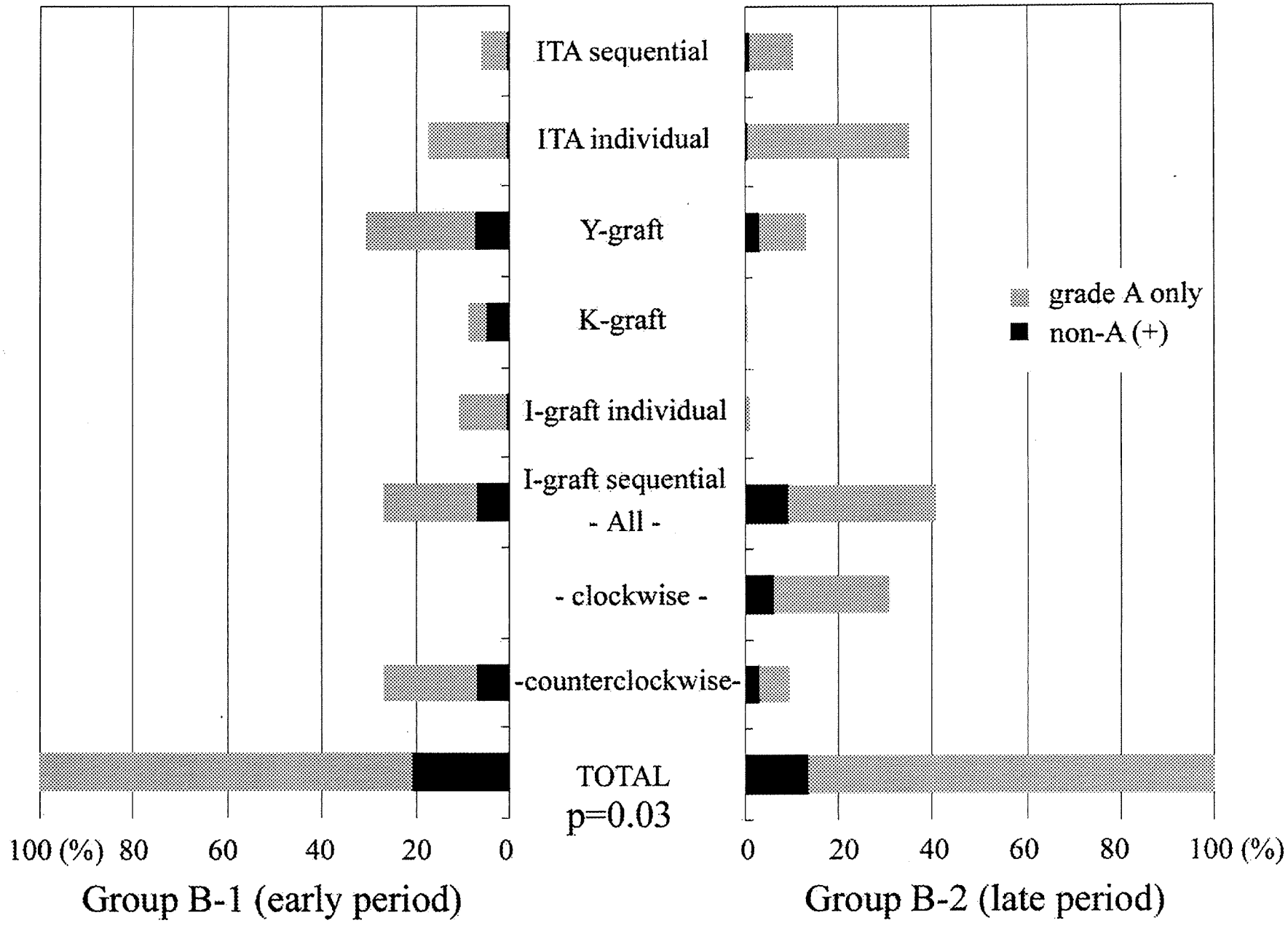
Figure 1

Figure 2


ITA sequential
ITA individual
Y-graft
K-graft
I-graft individual
I-graft sequential
- All -
- clockwise -
-counterclockwise-
TOTAL
p=0.03
grade A only
non-A (+)
100 (%) 80 60 40 20 0
0 20 40 60 80 100 (%)
Group B-1 (early period)
Group B-2 (late period)

冠疾患誌 2008: 14: 17-20

左冠動脈主幹部および近位部病変に対する両側内胸動脈使用の有用性：開存静脈グラフトからの competitive flow の可能性の検討

川村　匡，小林順二郎，中嶋　博之，舩津　俊宏，
伊庭　裕，八木原俊克，北村惣一郎

左冠動脈領域への大伏在静脈グラフト(SVG)の存在が内胸動脈(ITA)-前下行枝(LAD)グラフトの開存率へ与える影響について調べた．対象は1987年から2006年までに2枝バイパス(LAD，LCXそれぞれ1本ずつ)施行し，術後早期造影でグラフトの開存を確認した90例．全例in-situ ITA-LADグラフトを含み，composite graftおよびsequential graftを有する症例は除外した．LCXにITAを使用した43例(LCX-ITA群)とSVGを使用した47例(LCX-SV群)に分類した．遠隔期造影でのITA-LADグラフトの閉塞は6例で，全例LCX-SV群であった(p=0.02)．5年開存率はLCX-ITA群100%，LCX-SV群91%であった．LCX-SV群で両吻合部間に高度狭窄(90%以上)を有する場合(18例)と有さない場合(29例)で，ITA-LADグラフトの5年開存率を比較すると，高度狭窄を有する場合は100%で有さない場合は82%であった．両吻合部間に高度狭窄が存在しない場合，LCXへのSVGの選択はITA-LADグラフトの開存率に影響し，原因としてSVGからのcompetitive flowの可能性が示唆された．

KEY WORDS: ITA-LAD graft, SVG, competitive flow

Kawamura M, Kobayashi J, Nakajima H, Funatsu T, Iba Y, Yagihara T, Kitamura S: **Advantage of bilateral ITAs for LMT disease or proximal lesions on LAD and LCX; Investigation of negative influence of competitive flow from saphenous vein graft.** J Jpn Coron Asssoc 2008; **14**: 17-20

I. はじめに

冠動脈バイパス術におけるグラフト選択として，内胸動脈(ITA)の左前下行枝(LAD)への使用は，その高い開存率と遠隔期予後の改善[1-8]のため広く使用されている．その一方でITAグラフトにおいてはグラフト流量が不十分なときにはstring signを示す，あるいは閉塞すると報告され[9-14]，これは吻合した冠動脈の狭窄度が軽度でnative coronaryからの血流との競合(competitive flow)によることが多いとされている．また，ITAグラフトは上行大動脈を近位側吻合部とする大伏在静脈グラフト(SVG)と比較し，そのflow capacityが低いとされ[15,16]，ITAグラフトとSVGが共存する場合，開存するSVGの存在はITAグラフトの血流を減少させうる可能性が考えられ，ITA-LADグラフトの開存率に悪影響をもたらす懸念がある．そこで，左冠動脈主幹部(LMT)ならびにLADと回旋枝(LCX)の両近位部に比較的限局した症例に対する2枝バイパス症例の遠隔成績から，共存するグラフト間のcompetitive flowの可能性についての検討を試みた．

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II. 対象および方法

1987年から2006年までにLMT単独，LMTかつLADとLCX近位部すべてに，または，LADとLCX近位部(LMTなし)に有意病変を有する症例(図1)に2枝バイパスを施行した180例中in-situ ITA-LADバイパスを含む90例を対象とした．術直後のカテーテル検査は全例行っており，この検査にてLADまたはLCXへのバイパスどちらか一方でも閉塞を認めた症例は除外した．また，ITAをfree graftとした症例，composite graftを作成した症例，sequential吻合した症例も除外した．術後遠隔期のカテーテル検査は原則的に胸痛などの症状を呈した場合，もしくはグラフト閉塞あるいはnative冠動脈の狭窄が進行したと疑われた場合に施行した．LCXに使用したグラフト別に群分けを行い，ITAを使用した群(LCX-ITA群)43例，SVGを使用した群(LCX-SV群)47例であった(図2)．それぞれの群の患者背景を表1に示した．LCX-SV群は主に2000年以前，on pump症例が多く，LCX-ITA群は2000年以降，off pump症例が多い傾向にあった．2群間でそれぞれのITA-LADグラフトの遠隔期開存率を比較し，さらにLCX-SV群においては両グラフト吻合部間のnative coronaryの狭窄度とグラフト閉塞の関連を調べた．平均経過観察期間はLCX-ITA群で3.7±4.2年，LCX-SV群で7.7±5.6

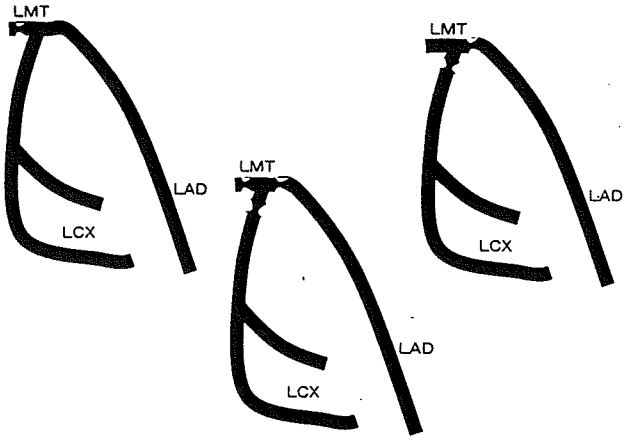

図1　対象とした病変

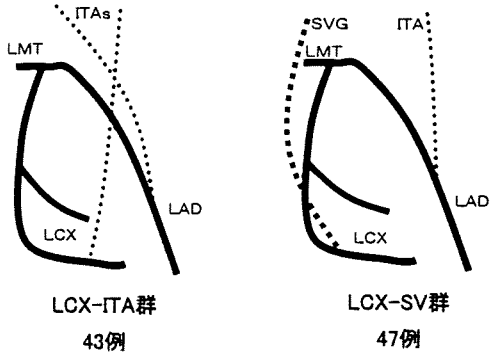

図2　LCX 領域に使用したグラフトによる群分け

表1　患者背景

	LCX-ITA 群 n=43	LCX-SV 群 n=47	p 値
手術時平均年齢	60.5±7.9	60.4±9.0	.992
平均経過観察期間(年)	3.7±4.2	7.7±5.6	.0004
主な手術時期	2000 年～	～2000 年	
性別(男：女)	38：5	37：10	.219
冠危険因子			
DM	21	20	.549
HT	29	17	.003
HL	28	19	.019
心機能			
EF<30%	3	1	.264
手術			
On pump	11	46	
Off pump	32	1	<.0001
遠隔期死亡	1	2	.622
発生イベント			
re CABG	0	1	.336
PCI	5	6(8 領域)	.869
領域 LAD	0	2	
領域 LCX	2	3	
領域 RCA	3	0	
領域 Graft	0	3	

年であった.

統計学的処理は unpaired Student's *t*-test, Mann-Whitney's U test を用いた. 累積開存率の解析は Kaplan-Meier 法で行った. それぞれの検定にて $p<0.05$ を有意差ありとした.

III. 結　果

遠隔期死亡例は LCX-ITA 群に1例, LCX-SV 群に2例認めた. LCX-SV 群の1例は原因不明であり, 他の2例は癌死であった. 再 CABG は LCX-SV 群に1例認め, PCI は LCX-ITA 群に5例, LCX-SV 群に6例認め, グラフトの狭窄に伴うものは LCX-SV 群のみ3例認めた.

ITA-LAD グラフトの閉塞は6例であり, すべて LCX-SV 群であった(p=0.02). 遠隔期開存率の比較では, LCX-ITA 群における ITA-LAD グラフトの開存率は5年で100%(2)〔()内はリスク保有数〕であり, LCX-SV 群における ITA-LAD グラフトの開存率は5年91%(14), 10年67%(7)で LCX-ITA 群において高値を示した(図3).

さらに, LCX-SV 群において両グラフト吻合部間の native coronary の狭窄度と ITA-LAD グラフトの開存率への影響の有無を検討した. ITA グラフトと SVG 間に90%狭窄以上(つまり冠動脈造影での最小血管径の実測値で76%以上の狭窄)の狭窄を有する群18例と有さない群29例(図4)で, ITA-LAD グラフトの開存率を比較したところ, 狭窄を有する群は10年で100%(5)であったのに対し, 狭窄を有さない群では5年開存率82%(6), 10年開存率34%(2)で, 狭窄を有さない群では開存率が有意に低かった(図5). ITA-LAD グラフトの閉塞例6例はすべて狭窄を有さない群であった(p=0.002).

IV. 考　察

冠動脈バイパス術における ITA の LAD への使用は gold standard ともいうべき確立されたものであるが[1-8], 標的

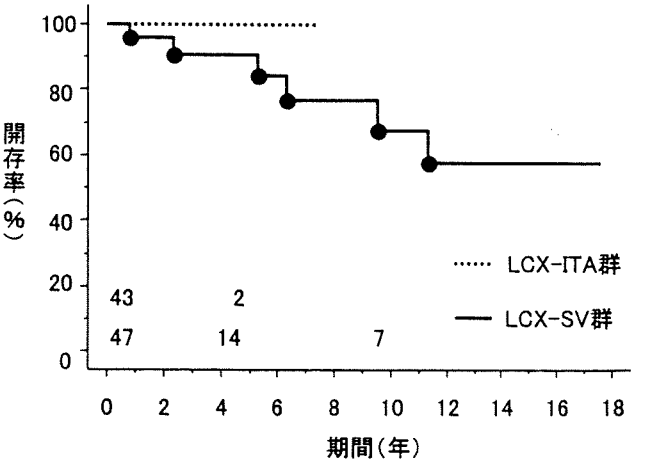

図3　LCX 領域に使用したグラフトの違いによる ITA-LAD グラフトの遠隔期開存率の比較

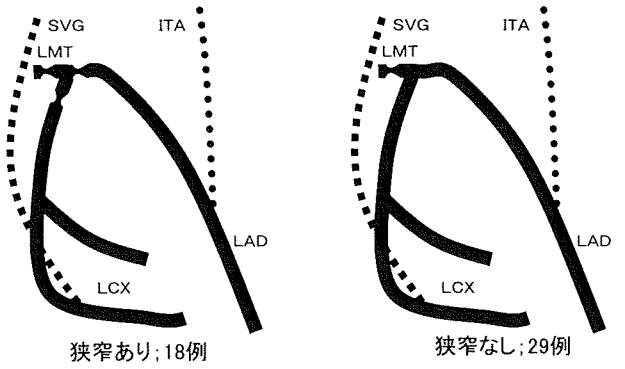

図4　LCX-SV群におけるLADとLCXグラフト吻合部間に存在する有意(90%以上)狭窄の有無による群分け

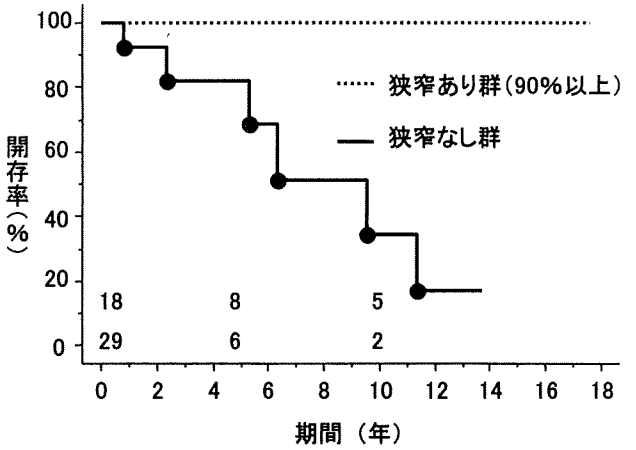

図5　LCX-SV群におけるLADとLCXグラフト吻合部間の冠動脈狭窄度で分けたITA-LADグラフトの遠隔期開存率の比較

冠動脈の狭窄が軽度である場合，血流が競合(competitive flow)し，結果としてstring signを示す，あるいは閉塞することも広く知られている[9-14]．

多枝病変に対しては，Schmidtら[15]の報告によると左冠動脈(LCA)領域に両側ITAを使用するほうが，ITAとSVGを使用した場合より遠隔成績が優れているとされる．LADへは一方のITAを使用し，LCX領域に対しても動脈グラフトを用いることが遠隔成績を向上させるとされ，さらに現在は全領域に対して動脈グラフトを使用することを標準的な術式としている施設が本邦では多い．

これまでに当施設では上行大動脈に手術操作を行わずに動脈グラフトのみで血行再建を行うバイパス術例を対象とし，native coronaryの狭窄度や血管径と複数の枝の組合せ，グラフト種類，composite graftの形とグラフトの血流分布への影響を調べ，グラフトの適切なデザインが遠隔期のグラフト開存率と心事故の回避につながることを報告してきた[16]．つまり，ITA-LADグラフトも含めて動脈グラフトを使用する際には適切なグラフトデザインが重要と考えている．さらに，バイパスグラフトが有効なcapacityを有しているかどうかについては，2つの因子，flow

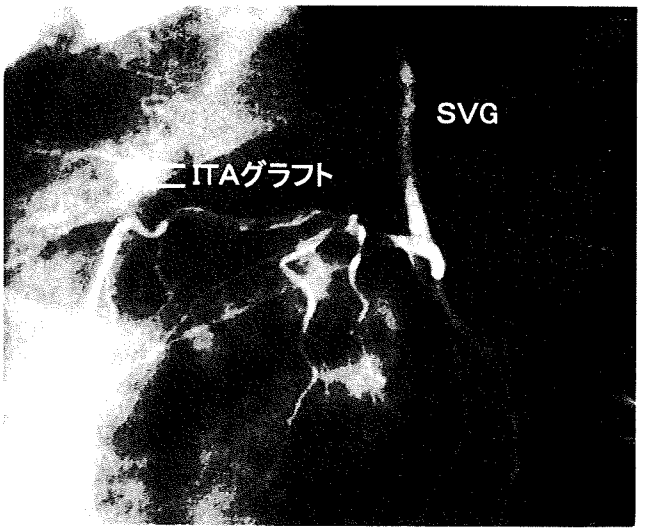

図6　CABG後術後6年目の冠動脈造影
SVGより注入された造影剤はLADの末梢まで到達し，さらに瘢痕様のITAも逆行性に造影された(矢印)

capacityとpressure capacityの観点からの評価が必要と考えられる．とくに，competitive flowの予測因子としてはバイパスグラフトとnative冠動脈の間の圧較差，つまりpressure capacityが重要であると考えている[17]．

SVGは冠動脈バイパスに使用した場合，独特の変性・硬化が進行するため，in-situ ITA-LADグラフトのような長期の開存性を期待することはできないとされている．しかし，一方で上行大動脈を近位側吻合部とすることで高い灌流圧を有する特徴がある[18,19]．そこでin-situ ITA-LADグラフトとSV-LCXグラフトなど，pressure capacityの異なる複数のグラフトが同一冠動脈領域に吻合されたとき，開存SVGの存在が予後を左右するとされるITA-LADグラフトの開存に影響する可能性がある．つまり，SVGの短所としてこれまで指摘されてきたSVG自体の開存率の低さだけでなく，他の重要な動脈グラフトの開存に影響する可能性も考えうるが，これまでにグラフト同士の影響や，静脈グラフトの適切な使用，至適なグラフトデザインの方法について十分議論がなされていない．

今回，共存する異なったグラフト間の長期間の影響についての純粋な比較検討を行うため，複雑でない冠動脈病変に対しシンプルなグラフトデザインの冠動脈バイパス術を施行し，なおかつ，術後早期の造影で開存していた症例のみを対象とした．このなかで遠隔期にITA-LADグラフトの閉塞を認めた6例では，すべてLCX領域にSVGが吻合され，いずれの症例もITAグラフトとSVG間のnative coronaryの狭窄度が軽度であった(有意狭窄なし5例，75%以下の狭窄1例)．さらに，これら6例のうち少なくとも3例においては，狭窄のないSVGからの造影剤の注入から，LADに吻合したITAまで逆行性に造影され，しかもITAがstring signを呈していた(図6)．これらのことからITA-LADグラフトの閉塞にはpressure capacityの高い

開存SVGの存在が強く影響し，これによりITAグラフト血流が不十分となり，最終的に閉塞に至った可能性が高いと考えられた．一方で，両側ITAのLCAへの使用はITA-LADの長期開存を障害することがなかった．これらのことより，ITAとSVGをLCA領域に使用すると遠隔成績が悪くなるとするこれまでの知見に対する理由付けとして，単にSVGの閉塞だけでなく，ITA-LADグラフトへの悪影響も理由のひとつと考えられる．今回の検討は限られた症例数のretrospective studyであり，今後同様の視点からの報告が増え，グラフトデザインについての議論が深まることが期待される．

以上のことからLCA領域にITAグラフトとSVGが共存する場合，LADへのバイパスの長期開存が脅かされ，グラフト間の影響は無視できないといえる．とくに両吻合部間のnative coronaryの狭窄度が軽度な場合，LCXに対するSVGの使用及びグラフトデザインは手術リスク等を十分に考慮し慎重に決定すべきと考えられた．

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Ann Thorac Surg
2007;83:1532–4

Hybrid Therapy for Rapid Enlargement of Hibernating Coronary Arteriovenous Fistulas

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The use of hybrid therapy for recurrent multiple coronary arteriovenous fistulas in a 56-year-old woman is reported. The patient underwent surgical closure of a coronary arteriovenous fistula of the right coronary artery under cardiopulmonary bypass at 47 years of age. Reoperation was required 9 years later for recurrence of the same fistula. It was divided under a beating heart. Early postoperative angiography showed complete occlusion of the right coronary fistula. However, hibernating fistulas of the left circumflex artery, which had been left untouched because of insignificant shunt with no remarkable change for 9 years, increased in size rapidly. Transcatheter embolization was successfully performed for these residual fistulas.

(Ann Thorac Surg 2007;83:1532–4)

Surgery for coronary arteriovenous fistula (CAVF) can be accomplished with very low morbidity and mortality [1–4]. Complete surgical closure of multiple CAVFs is sometimes difficult, however, because of complex anatomy and often, multiple sites of origin. This report describes a case of successful hybrid therapy in a 56-year-old patient with a late recurrent fistula of the right coronary artery (RCA) and hibernating fistulas of the left circumflex artery that showed rapid enlargement soon after closure of the RCA fistula.

A 46-year-old woman was referred to our institution for evaluation of a murmur. Selective coronary angiography visualized a large RCA fistula draining into the coronary sinus (Fig 1A). Small fistulas at distal sites of the circumflex artery were also noticed (Fig 1B). Oximetry demonstrated a 2.5:1 left-to right shunt.

At the age of 47 years, the patient underwent surgical correction under cardiopulmonary bypass and cardioplegia. The dilated RCA near the crux was opened, and the proximal opening of the fistula was closed directly. The

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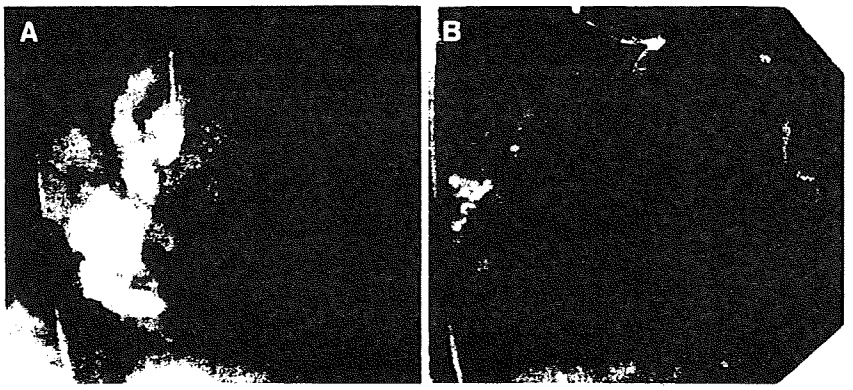

Fig 1. Coronary angiography before the initial operation. (A) A large right coronary fistula drained into the coronary sinus. (B) Fistulas of the left circumflex coronary artery were small.

circumflex fistulas were left untouched because of insignificant shunt. The patient made an uneventful recovery. Postoperative catheterization showed only a 1.08:1 left-to-right shunt despite a small residual shunt of the RCA.

When the patient was 56 years old, she repeatedly underwent cardiac catheterization because follow-up echocardiograms showed increased shunting. Coronary angiography showed similar findings to those in previous examinations of fistulas from both the RCA (Fig 2A) and circumflex artery (Fig 2B). Oximetry revealed a 1.72:1 left-to-right shunt.

Reoperation was performed through a repeat median sternotomy. The dilated RCA was shown to pursue a tortuous course along the epicardial surface of the right atrioventricular groove. Extracardiac dissection and isolation of the fistula were performed using a Starfish (Medtronic, Minneapolis, MN) heart positioner. The thickened fistula was divided after temporary occlusion of the fistula showed no ischemic response. Meanwhile, the circumflex fistulas were left because the shunt was insignificant, with no remarkable change for 9 years after the first preoperative coronary angiography.

On postoperative day 9, angiography showed that the dilated proximal RCA was occluded by thrombus (Fig 3A), and the distal RCA was filled by collateral arteries from the circumflex artery. Oximetry results almost normalized, with a 1.1:1 left-to-right shunt. An unexpected finding was that the sizes of the circumflex fistulas were significantly increased (Fig 3B). According to the coronary angiography findings, the fistulas had three feeding arteries from the end of the circumflex artery draining into the coronary sinus.

A percutaneous transcatheter embolization was therefore performed to occlude all feeding arteries, which was accomplished with 19 microcoils (GDCTM Fibered VortX Shape, Boston Scientific, Natick, MA; Fig 4). Two years after hybrid therapy, the patient's condition was good, and follow-up echocardiogram showed no significant shunting.

Comment

Coronary arteriovenous fistula is a rare congenital anomaly that can be complicated by congestive heart failure, angina, endocarditis, or rupture of a coronary aneurysm. Hence, early surgical intervention has been recommended to prevent the development of significant and potentially fatal complications. In addition, recent reports have emphasized the efficacy of percutaneous transcatheter techniques for the treatment of CAVF. The clinical decision of intervention or surgery is usually based on angiographic findings or an abnormal hemodynamic status.

In this patient, there were two issues in the clinical course. The first was the recurrence of the RCA fistula after the first operation. In the angiographic findings before the second operation, the location of the shunt flow was similar to that of the angiographic findings before the first operation. On the basis of these results, the cause of recurrence might have been dehiscence of friable tissue that was directly closed. The second issue

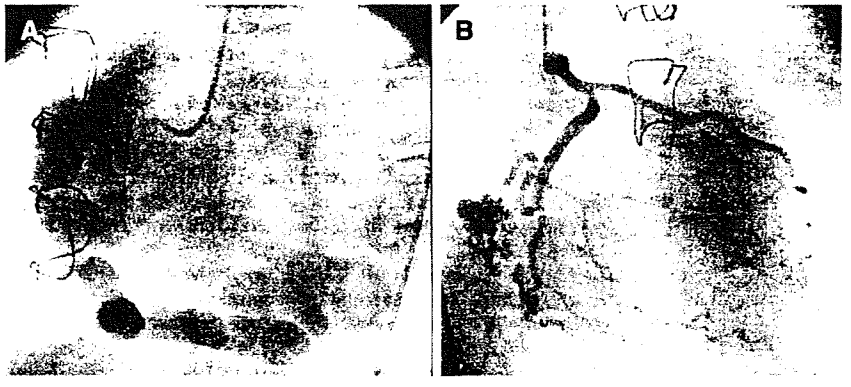

Fig 2. Coronary angiography before the second operation. (A) A recurrent right coronary fistula showed large shunting. (B) Circumflex fistulas showed no remarkable change and were still insignificant.

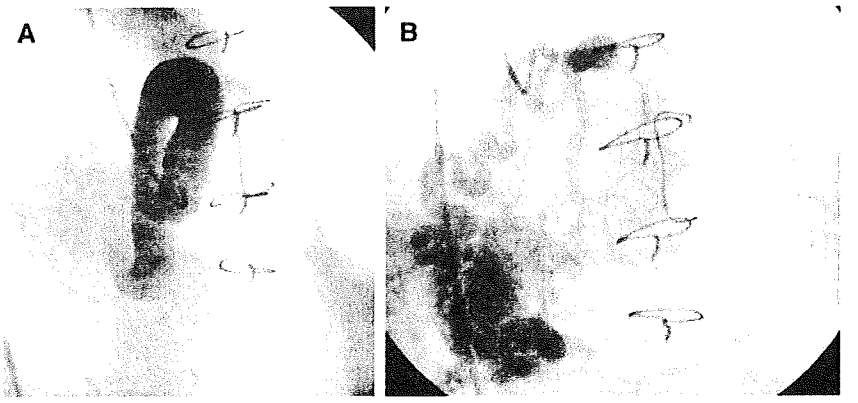

Fig 3. Coronary angiography after the second operation. (A) The dilated right coronary artery was occluded by thrombus. (B) Hibernating fistulas rapidly increased in size after closure of the main fistula.

was the rapid enlargement of the hibernating circumflex fistulas after the redo operation.

It is generally accepted that small asymptomatic fistulas should be managed conservatively because of the possibility of spontaneous closure [5, 6]; therefore, the circumflex fistulas, which were small and showed no remarkable change for 9 years, were ignored at the second operation. Regarding the potential long-term risk of enlargement, we considered elective transcatheter embolization. However, early postoperative angiography revealed that the hibernating fistulas rapidly increased in size, while the main fistula in the opposite coronary system disappeared and the dilated proximal RCA was thrombosed. Moreover, the distal RCA was opacified owing to retrograde flow from collateral arteries from the circumflex fistulas, which had not been recognized before. This showed that collateral circulation from the circumflex coronary system had rapidly increased to maintain the blood supply of the thrombosed RCA.

The phenomena of proximal thrombosis and distal circulation filled by collaterals have been reported as prevalent findings [4], but in this case we report opposite coronary fistulas hibernating for 9 years that showed rapid enlargement soon after closure of the main fistula. The precise mechanism of this rapid enlargement is difficult to prove, but we propose that the possible mechanism is the acute change of turbulent flow in the coronary sinus by abrupt termination of coronary blood flow from the RCA.

Transcatheter embolization was finally adopted to treat these multiple, growing fistulas. Several criteria exist for the performance of coil occlusion, such as absence of a single narrow drainage site, absence of large branch vessels, and safe access to the coronary artery. Close follow-up is also required because the long-term outcome after coil embolization remains unknown [7, 8]. Hybrid therapy should, however, be considered the treatment of choice for coronary arteriovenous fistulas that are difficult to close completely by surgical intervention because of complex anatomy and multiple sites of origin.

Fig 4. Left coronary angiography after coil embolization. Circumflex fistulas were occluded by percutaneous transcatheter embolization.

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Patency Rate of Internal Thoracic Artery to Left Anterior Descending Artery Bypass is Reduced by Competitive Flow from Concomitant Saphenous Vein Graft in Left Coronary Artery with Mildly Stenosed Lesion

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Abstract

Objective:

In coronary artery bypass grafting (CABG), utility of an in-situ internal thoracic artery (ITA) to the left anterior descending artery (LAD) is well accepted. However, an ITA graft shows 'string sign', when the graft flow in the bypass graft is not sufficient. Although moderate stenosis in the native coronary stenosis is reported as the commonest cause for this phenomenon, the patent SVG from ascending aorta can be a cause of insufficient flow in the in-situ ITA graft, because it has greater flow capacity than the in-situ ITA graft. In present study, we examined the negative impact of concomitant SVG in the left coronary artery (LCA) on the long-term patency of ITA to LAD bypass aiming at establishing optimal strategy for graft arrangement.

Methods:

We reviewed coronary angiograms of 313 patients who underwent CABG with two bypasses to LCA including one in-situ ITA to LAD graft and early postoperative angiography between March 1986 and December 2006. Patients who had an occluded graft in the early angiography, or had a composite or sequential graft, were excluded from this study. In 64 patients, bilateral ITAs were individually anastomosed to LAD and another LCA branch(BITA group). ITA to LAD and SVG to another LCA branch bypasses were performed in 249 patients(ITA/SV group). The mean follow-up period was 6.8±4.9 years.

Results:

The cumulative patency rate of ITA-LAD bypass at 10 years was 100% in BITA group, and 81.4% in ITA/SV group. 14(6%) of ITA-LAD bypass was occluded in ITA/SV group. When investigating with regard to a degree of native coronary stenosis between two anastomotic sites in ITA/SV group, the cumulative graft patency rate of ITA-LAD bypass at 5 years was 98.6% in patients with severe stenosis(>90%), whereas 82.3% in patients without severe stenosis($p<.0001$).

Conclusions:

Patency of the ITA to LAD bypass was affected by concomitant SVG to LCA, particularly when the native coronary stenosis between two anastomotic sites was not severe. Competitive flow from SVG could play an important role in failure of the ITA-LAD graft.

Introduction

In coronary artery bypass grafting (CABG), utilization of ITA has been decreased operative mortality and has not been increased operative complications (7.8). The internal thoracic artery (ITA) to the left anterior descending artery (LAD) in coronary revascularization has been proven to be superior long-term patency rate (1) and improving long-term mortality and morbidity for patients with coronary artery disease (2.3.4.5.6) compared to use of vein graft to the LAD.

On the other hand, it has been reported that the ITA graft has a significant disadvantage, that is, competitive flow in the ITA graft cause 'string sign', which represents narrowing of the artery along its whole length (9). Competitive flow can often arise either when the flow capacity of the graft is insufficient, or when the flow capacity of the native coronary artery is too high. Several previous studies revealed that the incidence of this phenomenon was inversely correlated with severity of native coronary stenosis (10.11.12).

Recently, in graft arrangement of CABG, various grafts, such as ITA, radial artery, gastroepiproic artery and saphenous vein graft (SVG) are applied and designed as various configurations. There are several reports investigating hemodynamic features of bypass grafts. Kawasuji and colleagues compared the flow capacities of arterial grafts and SVG and demonstrated that the flow capacity, which represented blood pressure in diastole, of the in-situ ITA graft was less than that of SVG, the proximal anastomosis of which put on the ascending aorta (13). Therefore, when the two bypass grafts, which had different blood pressure, were connected with the same coronary artery system, there may be negative interactions to each other. These negative effects of one bypass graft to the other graft have not fully delineated, yet.

The purpose of this study is to examine the effect of concomitant SVG on long-term patency of the ITA graft to LAD and to consider about an optimal graft arrangement in coronary revascularization.

Materials and Methods

We reviewed coronary angiograms of 313 patients who underwent CABG with two bypasses to LCA including one in-situ ITA to LAD graft and early postoperative angiography between March 1986 and December 2006. There was 263 men and 50 women with mean age of 60.9±8.9 years (table 1). CABG with two distal anastomoses in LCA was 93 patients and CABG with two distal anastomoses in LCA and one distal anastomosis in RCA was 220 patients. Second target branches in LCA were the diagonal branch (Dx; 43) or the left circumflex branch (LCX; 270). The kinds of grafts which applied for CABG in this study were ITA and SVG. All grafts were

individually anastomosed to target vessels. Patients were excluded from this study if they had an occluded graft in the early angiography, or had a composite or sequential graft.

All coronary angiographies were independently evaluated by cardiologists for the native coronary artery stenosis and the graft patency, respectively. The degrees of stenosis in the precise measurement of the minimal luminal diameter were graded as 51% to 75%, 76% to 90%, and 91% to 100%. The maximal severity of stenosis was recorded for all coronary branches.

Patients were divided into two groups according to graft selection in LCA (table 2). BITA group consisted of 64 patients. In this group, the bilateral in situ ITA were individually anastomosed to the LAD and another LCA branch (Dx or LCX)(figure 1). In ITA/SV group, 249 patients had a single in situ ITA to LAD and SVG to another LCA branch bypasses (Dx or LCX) were (figure 2). In our institution, off-pump CABG with total arterial revascularization has been introduced in 2000. At the baseline, in BITA group, off-pump CABG was carried out with significantly higher rate than in ITA/SV group. Comparing to ITA/SV group, patients with male sex and hypertension were included in BITA group with significantly higher rate. On the other hand, the population of CABG with three distal anastomoses was significantly higher in ITA/SV group than in BITA group.

Operative technique

In our institution, CABG has been carried out with off-pump technique from December 2000. Until December 2000, we performed on-pump CABG. The heart was exposed through a median sternotomy incision. On-pump CABG was done in a standardized fashion with ascending aortic cannulation and single venous cannulation of the right atrium. The core temperature was kept between 32° and 34°C. Intermittent tepid blood cardioplegia was infused antegradely and retrogradely. Our standard technique of off-pump CABG has been reported previously (14). A stabilizer and an apical suction device was used for off-pump CABG and a retract-O-tape (Quest Medical, Inc., Allen, TX) was placed for temporary proximal occlusion. While suturing coronary anastomosis, the surgical field was maintained by CO_2 blower and an intracoronary shunt (Anastaflo;Edward Lifescience, Irvine, California[for 1.5-mm and 2.0-mm vessels], or Clearview; Medtronic, Minneapolis,Minnesota[for 1.0-mm and 1.25-mm vessels]). In the present study, the ITA was harvested using either conventional (combined with vein and fascia), or semiskeletonized (partially combined with vein) or skeletonized technique (14). All distal portion of ITA grafts were larger than 1.5mm in diameter assessed by insertion of 1.5 mm flexible probe.

Long-term patency rate of the ITA to LAD bypass

We calculated long-term patency rate of the ITA-LAD bypass from late coronary angiogram and examined whether severity of the native coronary stenosis between two anastomoses site of LAD and LCX affected on the long-term patency rate of the ITA-LAD bypass. The mean follow-up period was 6.8±4.9 years. The repeated coronary angiograms (more than twice) were performed on 133 patients (42.5%;133/313).

Statistical analysis

The continuous variables are expressed as the mean values ± standard deviations, and compared by the unpaired Student's t-test between the two groups. The data of two independent groups were compared by Fisher's exact probability test. The Kaplan-Meier methods was used to determined the cumulative graft patency rate. The differences in the outcomes were considered statistically significant at a probability value <0.05.

Results

In ITA/SV group, 14 bypass grafts were occluded during the follow-up period(5.6%,14/249). In BITA group, all ITA-LAD bypasses were patent during follow-up period, whereas the cumulative patecy rate of the ITA-LAD bypass in ITA/SV group was 94.9% at 5 years, 81.4% at 10 years, respectively (figure 3).
The ITA/SV group was divided to two subgroups regarding to severity of native coronary stenosis between two distal anastomotic sites in LCA territory (figure 4) . The ITA/SV-I subgroup consisted of 189 patients and there was severe stenosis, which was defined as more than 76%, between two anastomostic sites in ITA/SV-I subgroup. Sixty patients belonged to ITA/SV-II subgroup and ITA/SV-II subgroup had less than 75% stenosis between two anastomoses sites. In the late results, 5 ITA to LAD grafts were occluded in ITA/SV-I subgroup(2.6%, 5/189), whereas 9 in ITA/SV-II subgroup(15%, 9/60),respectively.The cumulative patency rate of the ITA-LAD bypass in ITA/SV-I subgroup was 98.6% at 5 years, 91.2% at 10 years, respectively. On the other hand, the cumulative patency rate of the ITA-LAD bypass in ITA/SV-II subgroup was 82.3% at 5 years, 45.6% at 10 years, respectively (p<.0001)(figure 5).

Discussion

Some differences between ITA graft and SVG were reported. It is well known that the long-term patency rate and graft durability of the in-situ ITA is higher than that of the SVG. As a characteristics of the saphenous vein graft, Campeau and associates reported that atherosclerotic change, which was widely known as 'vein disease', was frequently found during long follow-up periods by means of sequential coronary angiography (18), while it rarely occur in the ITA graft. Moreover, regarding hemodynamics, SVG has higher flow capacity than that of the in-situ ITA graft (13). High flow capacity of SVG was owing to higher blood pressure in an aortocoronary bypass than that in the in-situ ITA graft, as well as its larger diameter than the in-situ ITA graft.

To examine long-term interactions between the different features of grafts, only patients who had a simple graft arrangement for coronary artery disease were included in the present study, whereas patients who had occluded graft in the early coronary angiogram were excluded. Especially, we focused on the chronic effects on the ITA-LAD bypass, because the patency of the ITA to LAD bypass is clinically important for survival of patients after CABG.

In the results, there was no occlusion of the ITA to LAD graft in patients bilateral ITAs were used. On the contrary, 14 ITA to LAD grafts were occluded in patients who had patent SVG to the other branch of left coronary artery (figure 3). These results suggested that type of second graft in LCA influenced to the patency rate of the ITA-LAD bypass and SVG could have negative impact on the ITA-LAD bypass. In addition, when we explored the patency rate of ITA-LAD bypass with concomitant SVG in LCA regarding to degree of native coronary stenosis between two distal anastomoses, the patecy rate of ITA-LAD bypass having moderate stenosis (less than 75%) between two distal anastomotic sites was significantly lower than that of ITA-LAD bypass having severe stenosis (more than 76%)(figure 5). These suggested that concomitant SVG affected on patency of the ITA-LAD bypass, particularly when the native coronary stenosis between two distal anastomoses in the LCA was not severe.

We carefully reviewed early and late coronary angiograms of the occluded ITA-LAD bypass of 4 patients. A representative case was shown in figure 6. An ITA graft, which anastomosed to the LAD, showed 'string sign' three years after the operation. On the other hand, SVG, which anastomosed to marginal branch, was well patent, and this strong bypass flow from SVG opacified not only LCX but also LAD. In addition, the ITA graft was visualized by retrograde flow from SVG injection. It suggested that the presence of the patent SVG and reduced blood flow in the ITA would be a reason for the ITA-LAD bypass failure. These results demonstrated that patent SVG

anastomosed to LCX could be a cause of competitive flow in the ITA to LAD and resultant the ITA-LAD bypass failure, and this would be a critical disadvantage of the venous graft.

Schmidt and colleagues reported the clinical results of CABG for patients undergoing isolated myocardial revascularization with bilateral ITAs and supplemental vein grafts. In their report, the cumulative survival rate of patients who received bilateral ITA grafts to branches of the left coronary artery showed a significant higher, as compared to that of patients who received bypsses of left ITA graft to the left coronary artery and right ITA graft to the right coronary artery (19). Previously, this was exclusively due to inferior patency of venous graft and importance of the circumflex artery over right coronary artery. However, inferior patency of ITA to LAD graft with the use of SVG to LCX, as shown in the present study, may be another possible explanation for superior prognosis of patients with bilateral ITA grafts to the branches of the left coronary artery.

We previously reported the significance of graft arrangement for long-term patency of multiple arterial grafts by examining the incidence of competitive and reverse flows in series of off-pump coronary revascularization with total arterial grafts and composite grafts (15.16.17). In these studies, the moderately stenotic right coronary artery (RCA) territory and the number of distal anastomotic site of the composite graft were significant predictors of the competitive flow and graft occlusion (15). In addition, some specific situations should be avoided for prevention of such flows (16). On the other hand, the type of composite graft and the diameter of the target coronary branch did not significantly correlate with the outcome (16). To achieve the advantages of arterial materials, and to minimize the incidence of cardiac events after CABG (17), we believe that graft arrangement with maximizing the antegrade bypass flow in the arterial grafts to the important coronary branch, such as LAD, plays important roles.

Limitations of the present study are as follows. First, this study is retrospective and non-randomized. The number of patients and bypass grafts were not enough to conclude this issue. In addition, progression of the native coronary stenosis and domonancy of the left or right coronary artery were not concerned. However, patients in this study are consecutive and results demonstrated obvious differences. The results of this study imply that suitability of venous graft to LCX should be carefully assessed. In patients who underwent CABG using both an in-situ ITA graft and SVG from the ascending aorta, we have to take a possibility of competitive flow from SVG into account, especially when the native coronary stenosis between the two target sites was not severe. The patency of the in-situ ITA graft would be affected by the whole graft arrangement, as well as the characteristics of coronary arteries, which included position

and severity of native coronary stenosis. In considering the optimal graft arrangement to receive benefits of arterial materials, theses results would be useful.

In conclusion, a patent SVG affected ITA-LAD graft patency, particularly when native coronary stenosis between the two distal anastomotic sites was not severe.

Competitive flow from not only native coronary artery but also SVG plays a crucial role in failure of the ITA bypass graft.

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