Slower progression of atherosclerosis in vein grafts harvested with 'no touch' technique compared with conventional harvesting technique in coronary artery bypass grafting: an angiographic and intravascular ultrasound study

Benny L. Johansson a,*, Domingos S.R. Souza b, Lennart Bodin c, Derek Filbey d, Andrzej Loesch e, Håkan Geijer f, Leif Bojö g

a Department of Cardiology, Örebro University Hospital, Örebro 70185, Sweden
b Department of Cardiothoracic Surgery, Örebro University Hospital, Örebro, Sweden
c Department of Biostatistics, Örebro University Hospital, Örebro, Sweden
d Department of Laboratory Medicine, Örebro University Hospital, Örebro, Sweden
e Department of Anatomy and Developmental Biology and Centre for Neuroscience, University College London, Gower Street, London, UK
f Department of Thoracic Radiology, Örebro University Hospital, Örebro, Sweden
g Department of Clinical Physiology, Central Hospital, Karlstad, Sweden

Received 25 November 2009; received in revised form 3 February 2010; accepted 4 February 2010; Available online 1 April 2010

Abstract

Objectives: In a long-term randomised coronary artery bypass grafting (CABG) study, the patency rate using a new 'no touch' (NT) vein-graft preparation technique was superior to the conventional (C) technique. This cineangiographic and intravascular ultrasound (IVUS) substudy examined possible mechanisms. Methods: A total of 45 patients (118 grafts) in the NT group and 46 patients (112 grafts) in the C group had patent grafts at short-term follow-up after 18 months. Thirty-seven patients (91 grafts) in the NT group and 37 patients (77 grafts) in the C group had patent grafts at long-term follow-up after 8.5 years, and were evaluated on a scale from 0 (normal) to 2 (significant stenosis) by cineangiogram. IVUS was performed in 15 NT grafts and 14 C grafts in the short-term follow-up, and 27 NT grafts and 26 C grafts in the long-term follow-up, in grafts considered normal by the cineangiogram. The grafts were evaluated with respect to lumen volume, intimal thickness, incidence of plaque and plaque components.

Results: In the short-term follow-up, the cineangiogram showed more normal grafts (89.0% in the NT group compared with 75.0% in the C group), and the number of grafts with stenosis was 11.0% in the NT group compared with 25.0% in the C group (p = 0.006). IVUS showed less mean intimal thickness (0.43 (0.07) mm vs 0.52 (0.08) mm; p = 0.03), less grafts with considerable intimal hyperplasia (>0.9 mm; 20% vs 78.6%; p = 0.011) and fewer patients with considerable hyperplasia (>0.9 mm; 25% vs 100%; p = 0.007). In the long-term follow-up, the cineangiogram showed more normal grafts, with 91.2% in the NT group compared with 83.1% in the C group; there were fewer grafts with significant stenosis, with 7.7% in the NT group compared with 15.6% in the C group (p = 0.14). IVUS showed fewer grafts containing multiple plaques (14.8% vs 50%; p = 0.008), less advanced plaque with lipid (11.8% vs 63.9%; p = 0.0004) and less maximal plaque thickness (1.04 (0.23) mm vs 1.32 (0.25) mm; p = 0.02) in the NT group compared with the C group. Conclusion: The superior long-term patency rate using the NT vein-graft technique at CABG could be explained by a significantly slower progression of atherosclerosis.

Keywords: CABG; Coronary artery bypass grafts; IVUS; Ischaemic heart disease; Revascularisation

1. Introduction

The success of coronary artery bypass grafting (CABG) is based on high rates of long-term graft patency. After CABG, however, the saphenous vein grafts show a high incidence of accelerated atherosclerosis. A major contributing factor to the early atherosclerotic process is damage to the vessel wall, especially endothelial injury that occurs during the conventional harvesting of the vein, using high-pressure distension [1—6]. A new 'no touch' (NT) technique, in which the saphenous vein is harvested with its pedicle of surrounding tissue, preserves the entire vein wall including the vasa vasorum [7—9]. In previous randomised prospective studies performed by our group, the NT technique showed superior patency rates compared with conventionally prepared vein grafts both in the short-term (18 months) and long-term (8.5 years) at cineangiographic follow-up. Furthermore, the clinical long-term follow-up showed more...
asymptomatic patients in the New York Heart Association (NYHA) class I in the NT group [10–12].

Results from the previous studies in which the NT group showed lower rates of graft occlusion and improved clinical outcome suggest that the NT-harvesting technique has a direct impact on overall outcome. These findings suggest that there should be detectable differences in the early stages of the atherosclerotic process in the vein grafts of patients treated with the NT technique compared with those treated with the conventional technique.

The aim of this study was to investigate if a delay in the atherosclerotic process of the saphenous vein grafts in the NT group could explain the previously demonstrated low rate of graft occlusion and the improved clinical outcome in the NT group. Accordingly, angiographically patent vein grafts were assessed by cineangiogram, and vein grafts considered normal by cineangiogram underwent intravascular ultrasound (IVUS) with respect to early atherosclerotic changes not detectable by the cineangiogram.

2. Material and methods

2.1. Study group

In a randomised prospective study performed during 1993–1995 at the Department of Thoracic Surgery, University Hospital of Örebro, Sweden, 104 patients (281 grafts) were randomised into two groups subjected to different techniques for harvesting the saphenous vein: in the patient group treated with conventional technique (the C group), the saphenous vein was stripped of surrounding tissue and distended with a pressure of 300 mmHg for 1 min (measured on a manometer); in the patient group treated with the NT technique (the NT group), the saphenous vein was harvested together with its cushion of surrounding tissue and was not distended.

In the short-term study (18 months), 91 patients (251 grafts) underwent a cineangiographic follow-up, including 45 patients (124 grafts) in the NT group and 46 patients (127 grafts) in the C group. A total of 118 out of 124 grafts in the NT group and 112 out of 127 in the C group were open and evaluated with respect to the degree of patency as established by the cineangiogram. An IVUS examination was performed in the last consecutive 18 patients (33 grafts) in which the cineangiograms were considered normal; these included nine patients (17 grafts) in the NT group and nine patients (16 grafts) in the C group. In the long-term study (8.5 years), 74 patients (202 grafts) underwent a cineangiographic follow-up, including 37 patients (101 grafts) in the NT group and 37 patients (101 grafts) in the C group. Ninety-one out of 101 grafts in the NT group and 77 out of 101 grafts in the C group were open and evaluated according to the degree of patency as established by the cineangiogram. An IVUS examination was performed in 29 out of 83 normal vein grafts (34.9%) in 15 NT group patients and 28 out of 64 normal vein grafts (43.8%) in 16 C group patients. The remaining patients refrained from participating in the IVUS substudy.

The study was approved by the ethics committee at our hospital; patients were included after providing written informed consent.

2.2. Cineangiographic analysis

The graft cineangiograms were performed according to Judkins technique [13]. Low osmolarity Visipaque® contrast medium, 320 mg iodine ml⁻¹ (Nycomed Amersham AB, Stockholm, Sweden) was used. All vein grafts were visualised in two projections. The cineangiographic assessment was performed by one radiologist blinded to the vein-graft preparation technique. The angiographic assessment of the patent vein grafts was classified according to a scale from 0 to 2, in which 0 = normal, 1 = non-significant stenosis and 2 = significant stenosis (≥50% diameter stenosis).

2.3. IVUS system and imaging procedure

We used a commercially available IVUS imaging system (Boston Scientific/Cardiovascular Imaging System, Inc., San Jose, CA, USA), which incorporated a single-element bevelled transducer mounted on the end of a flexible shaft and rotated at 1800 rpm within either a 2.9-French long monorail/common distal lumen imaging sheath or a 3.2-French short monorail imaging sheath.

After intragraft administration of 0.2 mg nitroglycerine and a bolus of 12 500 IU of heparin IV (IV, intravenous), IVUS imaging was performed, guided by the cineangiogram. If the native coronary artery was ≥2 mm in diameter and the angle between the graft and the native coronary artery was favourable, the ultrasound catheter was advanced into the native coronary artery. Otherwise, the probe was advanced as close as possible to the junction of the graft and the native coronary artery. An imaging run was then performed back to the aorto-ostial junction using an automatic pullback at 1 mm s⁻¹. The images were recorded on a high-resolution s-VHS tape (s-VHS, super video home system) for offline analysis.

2.4. IVUS image analysis

The IVUS assessment was performed by a cardiologist blinded to the vein-graft preparation technique. All measurements and calculations were performed manually using the calculation program incorporated in the IVUS system.

2.5. Graft lumen volumes

For each vein graft, the lumen area was calculated every millimetre, starting in the aorto-ostial junction and continuing throughout the graft. The lumen–intimal border was identified and traced manually, and the area within this border was considered as the lumen area. To estimate the graft lumen volume, each millimetre in the graft was considered a cylinder with a height of 1 mm and a base area equal to the average of the environ lumen areas, and the volume of this cylinder was then calculated. The graft lumen volume was determined as the sum of all these volumes throughout the entire graft.

2.6. Intimal thickness

The (lumen + intimal) area was calculated every second millimetre as well as the lumen area. The intimal area was
calculated by subtracting the lumen area from the (lumen + intimal) area. Assuming that the lumen and the (lumen + intimal) areas were approximately circular allowed an estimation of the average intimal thickness. The average radii of the lumen and the (lumen + intima) areas were calculated using the formula: area = πr². The intimal thickness was then calculated by subtracting the radius of the lumen from the radius of the (lumen + intima) every second millimetre. The average intimal thickness in each graft was finally calculated by taking the average of all measurements every second millimetre in each graft.

2.7. Plaque

The (lumen + intima media) area and lumen area were calculated every second millimetre. The plaque area was calculated by subtracting the lumen area from the (lumen + intima media) area. An echolucent area within the intima media was considered a lipid pool. The lipid, fibrosis and calcification content was evaluated and considered significant if detected in an arc ≥30° in two consecutive Images 2 mm apart.

2.8. IVUS variables

The evaluated IVUS variables included graft lumen volume, mean and maximal intimal thickness, intimal hyperplasia, % intimal hyperplasia of total graft length, occurrence of plaque, plaque grading (soft, fibrotic, calcified and mixed), maximal plaque thickness and % plaque burden of total graft length.

2.9. Statistical analysis

Data are presented as absolute and relative frequencies, n (%), mean values and standard deviation (SD) or medians and interquartile range depending on metric properties. Group differences in nominal and ordinal data were analysed by the chi-square test adapted for small samples. Data with metric properties corresponding to continuous data were analysed with a mixed model similar to a linear regression analysis extended with correlations between repeated measures in the case of more than one graft from the same patient. The model estimated the difference in averages between the NT and C groups; the difference was supplemented with 95% confidence interval (CI) and the p value for no difference between the groups. In all analyses, a p value <0.05 was considered statistically significant. The computations were performed with the program packages StatXact (Cytel Inc., Cambridge, MA, USA) and SAS (SAS Institute Inc., Cary, NC, USA).

3. Results

3.1. Cineangiogram

3.1.1. Short term

All patent vein grafts (118 grafts from 45 patients in the NT group and 112 grafts from 46 patients in the C group) were evaluated by cineangiogram. No complications occurred during or after the cineangiogram. A total of 105 vein grafts (89.0%) in the NT group were considered normal compared with 84 grafts (75.0%) in the C group; the number of grafts with stenosis was 13 (11.0%) in the NT group compared with 28 (25.0%) in the C group (p = 0.006).

3.1.2. Long term

All patent vein grafts (91 grafts from 37 patients in the NT group and 77 grafts from 37 patients in the C group) were evaluated by cineangiogram. No complications occurred during or after the cineangiogram. A total of 83 vein grafts (91.2%) in the NT group were considered normal compared with 64 grafts (83.1%) in the C group; the number of grafts with significant stenosis was seven (7.7%) in the NT group compared with 12 (15.6%) in the C group (p = 0.14). The remaining two grafts were non-significantly stenosed, one in each group.

3.2. IVUS

3.2.1. Short term

During the IVUS procedure, one patient in the C group had transient chest pain with electrocardiogram (ECG) changes, which disappeared directly after the procedure and was considered to be due to spasm. No infarction occurred. One patient in the NT group had a local bleeding complication, but did not require blood transfusion or surgery. In each group, one patient (two grafts) was excluded due to technical problems or poor image quality. The IVUS examination was analysed in eight patients (15 grafts) in the NT group and eight patients (14 grafts) in the C group.

Comparison of the NT group to the C group revealed that IVUS showed less mean intimal thickness, with 0.43 (0.07) mm versus 0.52 (0.08) mm (p = 0.03, 95% CI −0.9 to −0.01), less grafts with considerable intimal hyperplasia (≥0.9 mm), with 20% versus 78.6% (p = 0.011), less patients with considerable hyperplasia (≥0.9 mm), with 25% versus 100% (p = 0.007) and a tendency towards larger graft lumen volumes, with 120.3 (48.9) versus 89.3 (23.9) mm³/10 mm (p = 0.07, 95% CI −3.52 to 66.86) in the NT group. No lipid deposits, fibrosis or calcifications were detected in any graft in the two groups.

3.2.2. Long term

During the IVUS procedure, two patients in the C group and one patient in the NT group had transient chest pain with ECG changes that disappeared directly after the procedure and was considered to be due to spasm. No infarction occurred. Two patients in each group had local bleeding complications, but did not require blood transfusion or surgery. One patient (two grafts) in both groups was excluded due to technical problems or poor image quality. The IVUS examination was analysed in 14 patients (27 grafts) in the NT group and 15 patients (26 grafts) in the C group.

The baseline characteristics of patients are shown in Table 1. The results of the IVUS investigation at long-term follow-up are presented in Table 2.
lipid (11.8% vs 63.9%; p = 0.0004), less maximal plaque thickness (1.04 (0.23) mm vs 1.32 (0.25) mm; p = 0.02; 95% CI −0.49 to −0.06) and a trend towards fewer patients with grafts containing plaque (50% vs 80%; p = 0.13) in the NT group compared with the C group, respectively. No difference was seen in mean intimal thickness (0.50 (0.08) mm vs 0.53 (0.09) mm; p = 0.41; 95% CI −0.07 to 0.03) in the NT group compared to the C group. The lumen volumes were larger in the NT group compared with the C group (135.8 (46.5) mm$^3$/10 mm vs 109.7 (32.3) mm$^3$/10 mm; p = 0.03; 95% CI 2.56—49.50) (Fig. 1).

### Table 1
Clinical characteristics of patients who underwent IVUS long-term follow-up.

<table>
<thead>
<tr>
<th></th>
<th>‘No touch’ technique group</th>
<th>Conventional technique group</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of patients</td>
<td>14</td>
<td>15</td>
</tr>
<tr>
<td>Male</td>
<td>14 (100%)</td>
<td>12 (80%)</td>
</tr>
<tr>
<td>Age</td>
<td>67.4 ± 4.5</td>
<td>65.3 ± 8.5</td>
</tr>
<tr>
<td>Heredity</td>
<td>7 (50%)</td>
<td>10 (66.7%)</td>
</tr>
<tr>
<td>Diabetes</td>
<td>3 (21.4%)</td>
<td>3 (20%)</td>
</tr>
<tr>
<td>Hyperlipidaemia</td>
<td>14 (100%)</td>
<td>13 (86.7%)</td>
</tr>
<tr>
<td>Smokers</td>
<td>0 (0%)</td>
<td>2 (13.3%)</td>
</tr>
<tr>
<td>Hypertension</td>
<td>8 (57.1%)</td>
<td>3 (20%)</td>
</tr>
<tr>
<td>Previous AMI</td>
<td>7 (50%)</td>
<td>9 (60%)</td>
</tr>
<tr>
<td>Betablocker</td>
<td>9 (64.3%)</td>
<td>7 (46.7%)</td>
</tr>
<tr>
<td>Ca-inhibitor</td>
<td>2 (14.3%)</td>
<td>1 (6.7%)</td>
</tr>
<tr>
<td>ASA</td>
<td>14 (100%)</td>
<td>14 (93.3%)</td>
</tr>
<tr>
<td>Statins</td>
<td>13 (92.9%)</td>
<td>10 (66.7%)</td>
</tr>
<tr>
<td>ACE-Inhibitor</td>
<td>6 (42.9%)</td>
<td>5 (33.3%)</td>
</tr>
<tr>
<td>S-cholesterol (mmol l$^{-1}$)*</td>
<td>5.1 ± 0.8</td>
<td>5.3 ± 0.9</td>
</tr>
<tr>
<td>S-LDL (mmol l$^{-1}$)*</td>
<td>3.0 ± 1.0</td>
<td>3.2 ± 2.3</td>
</tr>
<tr>
<td>≤2.5</td>
<td>33.8%</td>
<td>26.7%</td>
</tr>
<tr>
<td>2.6–3.5</td>
<td>58.5%</td>
<td>40.0%</td>
</tr>
<tr>
<td>≥3.6</td>
<td>7.7%</td>
<td>33.3%</td>
</tr>
<tr>
<td>S-HDL (mmol l$^{-1}$)*</td>
<td>1.3 ± 0.4</td>
<td>1.4 ± 0.5</td>
</tr>
<tr>
<td>S-Triglycerides (mmol l$^{-1}$)*</td>
<td>1.8 ± 1.0</td>
<td>1.7 ± 0.8</td>
</tr>
<tr>
<td>B-glucose (mmol l$^{-1}$)</td>
<td>6.3 ± 1.2</td>
<td>7.0 ± 2.0</td>
</tr>
<tr>
<td>Systolic blood pressure (mmHg)</td>
<td>153 ± 20.3</td>
<td>147 ± 19.5</td>
</tr>
<tr>
<td>Diastolic blood pressure (mmHg)</td>
<td>81 ± 7.6</td>
<td>81 ± 5.4</td>
</tr>
</tbody>
</table>

Note: Data are shown as n (%) or mean ± SD with the exception of those parameters with a somewhat skew distribution; marked *, where median ± interquartile range is used.

### Table 2
Long-term IVUS results in vein grafts considered normal by the cineangiogram.

<table>
<thead>
<tr>
<th></th>
<th>‘No touch’ group</th>
<th>Conventional group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients (n)</td>
<td>14</td>
<td>15</td>
</tr>
<tr>
<td>Patients with plaque</td>
<td>7 (50%)</td>
<td>12 (80%)</td>
</tr>
<tr>
<td>Grafts (n)</td>
<td>27</td>
<td>26</td>
</tr>
<tr>
<td>Grafts with plaque</td>
<td>9 (33.3%)</td>
<td>16 (61.5%)</td>
</tr>
<tr>
<td>Plaque/diseased graft</td>
<td>1.89 ± 1.17</td>
<td>2.25 ± 1.00</td>
</tr>
<tr>
<td>Plaque length (mm)</td>
<td>8.1 ± 6.2</td>
<td>11.3 ± 6.6</td>
</tr>
<tr>
<td>Maximal plaque thickness (mm)</td>
<td>1.04 ± 0.23</td>
<td>1.32 ± 0.25</td>
</tr>
<tr>
<td>Total graft length (mm)</td>
<td>2227</td>
<td>2469</td>
</tr>
<tr>
<td>Total plaque length (mm)</td>
<td>138 (6.2%)</td>
<td>399 (16.2%)</td>
</tr>
<tr>
<td>Plaque</td>
<td>17</td>
<td>36</td>
</tr>
<tr>
<td>Superficial fibrosis or calcification (only)</td>
<td>12</td>
<td>1</td>
</tr>
<tr>
<td>Soft</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Mixed</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>Soft + lipid</td>
<td>1</td>
<td>13</td>
</tr>
<tr>
<td>Mixed + lipid</td>
<td>1</td>
<td>10</td>
</tr>
</tbody>
</table>

Note: Statistical analysis of parameters is given in text.

### 4. Discussion

The main challenge associated with CABG surgery using vein grafts has been the problematic high rates of graft stenosis or occlusion. Manipulation of the vein, especially the high-pressure distension used to overcome the spasm that occurs during preparation, has been proposed to be the cause of significant damage to the entire vein wall, in particular the endothelium. This damage will lead to a subsequent increased risk of thrombosis in the short-term, and neo-intimal proliferation, plaque formation and occlusion in the long term [1,2,4–6,14].

The NT technique, in which the saphenous vein is harvested with a pedicle of surrounding tissue, maintains an entire intact vein wall, which protects against spasm, thereby obviating the need for high-pressure distension. This leads to preservation of endothelial nitric oxide synthase (eNOS), not only of the luminal endothelium, but also of the media and adventitia, resulting in increased thrombo-resistance, superior vaso-relaxation and abolition of venous spasm [7,8,15,16]. A low rate of graft occlusion, both in the short and long term, and a better clinical outcome has been observed in previous prospective and randomised long-term CABG studies in our hospital using this technique [10–12]. This article elucidates possible explanations for these findings.

An adaptation of the vein graft wall to the arterial circulation with both increased graft size and intima/wall thickening has been demonstrated in previous IVUS studies [17,18]. Hozumi et al. [18] revealed an increase of the average intimal thickness of vein grafts, from 0.31 mm at 1 month to 0.65 mm after 12 months. In comparison, the present study showed an average intimal thickness of 0.52 mm in the C group and 0.43 mm in the NT group after 18 months. In addition to the significantly reduced average intimal thickness in the NT group, only 20% of the vein grafts in the NT group had a maximal intimal thickness ≥0.9 mm compared with 78.6% of the grafts in the C group. These results suggest that the early atherosclerotic process in the vein grafts is retarded by the NT-harvesting technique. A
possible contributing factor to slower developing graft disease when the NT technique is used may be that the pedicle of surrounding tissue provides a mechanical support to the vein wall, which may be beneficial in reducing intimal hyperplasia. This hypothesis is supported by the results of two studies in pigs, in which an ‘external stent’ placed around the vein grafts caused a pronounced reduction of intimal hyperplasia of 75% after 1 month and 97% after 6 months compared to unstented grafts [19,20].

Previous studies have suggested that the intimal hyperplasia in conventional vein grafts could be a forerunner of atherosclerotic plaque formation and subsequent graft occlusion [21–23]. This speculation is supported by our long-term results. In angiographically normal vein grafts, IVUS showed a twofold increase in grafts containing plaque and a threefold increase in diffuse plaque burden in the C group compared with the NT group. The same trend was observed in the cineangiograms, which reflected a doubling of grafts containing non-significant and significant stenosis in the conventional group. This is also consistent with the over twofold increase in the graft occlusion rate (24% vs 10%) in the conventional group observed in the same study [11].

Recent studies have shown that in native coronary arteries, soft plaques, especially those containing lipid, are prone to progress and cause acute coronary syndromes [24,25]. Therefore, it is very interesting to note that 63.9% of the plaque in the C group contained lipid compared with 11.8% in the NT group. There were no differences between the entire C and NT groups with respect to basic characteristics including blood lipids and other risk factors [12]. However, in the subgroups included in the present IVUS study, the patients from the C group compared with those from the NT group had a more unfavourable lipid profile, although not significant, with higher values of low-density lipoprotein (LDL) and total cholesterol and fewer patients treated with simvastatin (Table 1).

One of the aims of this article was to use IVUS to compare the NT group and C group with respect to the extent of early signs of vein-graft atherosclerosis. One limitation in our study is that the IVUS results from short-term analysis are based on only 15% of the total normal vein grafts compared with 40% in the long-term study. Therefore, comparisons of the results of both short-term and long-term follow-up must be evaluated with caution.

To the best of our knowledge, this is the first study demonstrating that a new surgical technique, the NT method of saphenous vein-graft harvesting, leads to a slower progression of vein-graft atherosclerosis compared with a conventional surgical technique.

5. Conclusion

The results of our study support the hypothesis that the superior long-term patency rate using the NT vein-graft harvesting technique in CABG can be explained by a significantly slower progression of atherosclerosis in these vein grafts compared with grafts harvested with conventional technique.

References

nolytic activity and histology with in vitro venous distention and arterial
RG. Optimal techniques for harvesting and preparation of reversed
autogenous vein grafts for use as arterial substitutes: a review. Surgery
dependence of damage induced by distension of human saphenous vein
685–91.
562–8.
coronary bypass induced by pressure and ischemia. J Thorac Cardiovasc
using saphenous vein harvested with its surrounding tissue for coronary
artery bypass grafting maintains an intact endothelium. Scand Cardiovasc
Human saphenous vein and coronary bypass surgery: ultrastructural
aspects of conventional and ‘‘no-touch’’ vein graft preparations. Histol
Improved patency in vein grafts harvested with surrounding tissue:
results of a randomized study using three harvesting techniques. Ann
Arbeus M, Dashwood MR. Harvesting the saphenous vein with surrounding
tissue for CABG provides long-term graft patency comparable to the left
internal thoracic artery: results of a randomized longitudinal trial. J
[12] Johansson BL, Souza DS, Bodin L, Filibey D, Bojo L. No touch vein harvest-
ting technique for CABG improves the long-term clinical outcome. Scand
[14] Liu ZG, Liu XG, Yim AP, He GW. Direct measurement of nitric oxide release
from saphenous vein: abolition by surgical preparation. Ann Thorac
[15] Tsiu JC, Souza DS, Filibey D, Bomfim V, Dashwood MR. Preserved endothel-
ial integrity and nitric oxide synthase in saphenous vein grafts harvested
[16] Tsiu JC, Souza DS, Filibey D, Karlsson MG, Dashwood MR. Localization of
nitric oxide synthase in saphenous vein grafts harvested with a novel ‘‘no-
touch’’ technique: potential role of nitric oxide contribution to improved
changes in angiographically normal saphenous vein coronary bypass grafts
Use of intravascular ultrasound for in vivo assessment of changes in
intimal thickness of angiographically normal saphenous vein grafts one
eye and neointimal thickening in a pig model of arteriovenous
of external stent size on early medial and neointimal thickening in a pig
GD. Nitric oxide synthase and adenylyl and guanylyl cyclase activity in
[22] Ratiliff NB, Myles JL. Rapidly progressive atherosclerosis in aortocorona-
ry saphenous vein grafts. Possible immune-mediated disease. Arch Pathol
