No-Touch Sequential Saphenous Venous Harvesting Technique in Off-Pump Bypass Surgery: A Retrospective Study

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Research Article

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Abstract

Background

In the mid-1990s, the Swedish expert team proposed saphenous vein graft (SVG) harvesting with pedicle tissue. The short-term and long-term patency rates of the great saphenous vein obtained by the no-touch technique (NT) were higher than those obtained by the conventional technique (CON). In the past, NT technology was mainly used in on-pump coronary artery bypass grafting (CABG), and vein grafts were mostly single vein grafts. In this study, we retrospectively analysed the safety and effectiveness of sequential vein grafts using NT technology in off-pump CABG.

Methods

From 2017 to 2019, a total of 505 patients were included in the study. There were 150 patients in the NT group and 355 patients in the CON group. After applying propensity score matching (1:1 matching), 148 patients were included in each group. Baseline data, graft patency, postoperative complications, leg wound complications and 1-year major adverse cardiac and cerebrovascular events (MACCEs) were compared between the two groups.

Results

There was no significant difference in the patency rate of sequential venous grafts between the two groups one year after the operation either before (NT: 7.1% (10/141) vs CON: 11.5% (38/331), $p = 0.149$) or after matching (NT: 7.1% (10/140) vs CON: 7.3% (9/124), $p = 0.971$). There was no significant difference in the composite clinical endpoint between the two groups either before (NT: 3 (2.3%) vs CON: 9 (2.8%), $p = 1.000$) or after matching (NT: 3 (2.3%) vs CON: 3 (2.5%), $p = 1.000$). There were differences in leg wound complications between the two groups both before (NT: 9 (6.9%) vs CON: 6 (1.9%), $p = 0.007$) and after matching (NT: 9 (6.9%) vs CON: 2 (1.7%), $p = 0.043$).

Conclusions

The application of the NT technique in off-pump CABG with sequential vein grafts is safe and effective. Leg wound complications are more common with the NT technique than with the conventional technique.

Introduction

Coronary artery disease is a serious threat to human health, especially complex coronary artery disease. At present, CABG is a good remedy for coronary artery diseases that are difficult to manage with interventional treatment. For CABG, the short-term and long-term patency rates are closely related to quality of life[1, 2]. Additionally, the patency rates of grafts are closely related to the choice of vascular materials, of which the internal mammary artery is undoubtedly the best[3]. An increasing number of studies have shown that the patency rate of the radial artery is also considerable[4]. However, arterial materials have some disadvantages,

such as easy spasm, limited length, and high occlusion rate when the target vessel stenosis is less than 90% [5]. Therefore, the proportion of procedures using the great saphenous vein remains high. However, the great saphenous vein has relatively low short-term and long-term patency rates is prone to occlusion, so it is important to determine ways to improve the patency rate of vein grafts[6]. In the mid-1990s, a team of Swedish experts proposed harvesting the great saphenous vein with pedicle tissue, that is, retaining part of the surrounding tissue in the process of harvesting the great saphenous vein and not expanding the vein manually after harvesting[7]. They also conducted a short-term and long-term follow-up study that showed that the short-term and long-term patency rates of the great saphenous vein obtained by NT technology were higher than those obtained by the conventional procedure, especially in the long-term follow-up[8, 9]. Some studies have showed that the NT grafts have excellent patency similar to that of radial artery (RA) grafts in long-term[10]. NT technology is undoubtedly of great help in improving the patency rate of venous grafts[11–13].

As technological innovations continue to be developed, CABG has been increasingly performed in off-pump mode, which not only allows for faster patient recovery but also results in fewer postoperative complications[14]. In addition, many studies have shown that there is no substantial difference between single vein and sequential vein grafts[15–17]. Previous studies mainly used NT technology in on-pump CABG, and most of the vein grafts were single vein grafts. Therefore, this study retrospectively analysed the safety and effectiveness of sequential vein grafts harvested by NT technology in off-pump CABG.

Methods

Patient Characteristics

From 2017 to 2019, 615 patients were selected, including 165 patients treated with NT technology and 450 patients with conventional technology. Finally, a total of 505 patients were included in the study. As shown in Figure 1, a total of 150 patients were enrolled in the NT group, and 355 patients were enrolled in the CON group. The baseline data of the two groups were compared. There were differences in sex, body mass index (BMI), smoking, hypertension, previous percutaneous coronary intervention (PCI) history and New York Heart Association (NYHA) classification between the two groups. After applying propensity score matching (1:1 matching), 148 patients were included in each group. There was no significant difference in the baseline data of the matched groups, as shown in Table 1. We promised that our experiment for involving humans was in accordance to guidelines of the Declaration of Helsinki. This study was approved by the Ethics Committee of Beijing Anzhen Hospital (Approval Numbers: 2018036X). Informed consent was obtained from all individual participants included in the study.

Table 1
Preoperative Characteristics and Risk Factors of Study Patients

Variables	All study patients			Propensity-matched patients		
	Group NT (n = 150)	Group CON (n = 350)	P value	Group NT (n = 148)	Group CON (n = 148)	P value
Age (years), mean ± SD	59.8 ± 9.0	60.5 ± 9.0	0.423	59.9 ± 8.9	60.4 ± 8.6	0.605
Female, n (%)	13(8.7)	76(21.4)	0.001	13(8.8)	16(10.8)	0.557
BMI>25(kg/m^2), n (%)	94(62.7)	181(51.0)	0.016	92(62.2)	90(60.8)	0.811
Smoking, n (%)	73(48.7)	137(38.6)	0.036	72(48.6)	83(56.1)	0.20
Hypertension, n (%)	100(66.7)	176(49.6)	< 0.001	98(66.2)	100(67.6)	0.805
Diabetes mellitus, n (%)	63(42.0)	121(34.1)	0.091	62(41.9)	70(47.3)	0.350
Previous MI, n (%)	57(38.0)	128(36.1)	0.679	57(38.5)	60(40.5)	0.721
Previous PCI, n (%)	23(15.3)	32(9.0)	0.037	22(14.9)	19(12.8)	0.614
Stroke, n (%)	16(10.7)	30(8.5)	0.429	16(10.8)	16(10.8)	1.000
NYHA, n (%)			< 0.001			0.485
I	2(1.5)	3(0.8)		2(1.4)	2(1.4)	
II	109(72.7)	161(45.4)		107(72.3)	101(68.2)	
III	36(24.0)	182(51.3)		36(24.3)	43(29.1)	
IV	3(2.0)	9(2.5)		3(2.0)	2(1.4)	
LVEF(%)<45%, n (%)	6(4.0)	20(5.6)	0.448	6(4.1)	11(7.4)	0.212
Left main disease, n (%)	51(34.0)	102(28.7)	0.239	50(33.8)	49(33.1)	0.902

NT: No-touch saphenous vein graft harvesting; CON: Conventional saphenous vein graft harvesting; BMI: Body mass index; MI: Myocardial infarction;PCI: Percutaneous coronary intervention; NYHA: New York Heart Association; LVEF: Left ventricular ejection fraction.

Operative Strategies

NT group

When harvesting the great saphenous vein, approximately 0.5cm of tissue on both sides of the main vein was preserved without destroying the adventitia. The visible branches of the main vein were ligated with ligation wire, and the left and right sides were clamped with silver clips. After the vein was obtained, it was stored in a mixture of heparin and papaverine without manual dilation. After anastomosing with the proximal end of the

ascending aorta, the blood pressure of the ascending aorta was used to check whether there was branch leakage in the main vein. If so, silver clips were used for clamping. After all anastomoses were completed, the sequential venous graft was checked again for blood leakage.

CON group

When obtaining the great saphenous vein, the surrounding tissue was not preserved, and the branches were treated in the same way as in the NT group. After harvesting, the vein was manually dilated with a syringe filled with heparin saline to check for branch leakage. The remaining operation procedures were the same as those used for the NT group.

CCTA Evaluation of Graft Patency

One year after the operation, cardiac computed tomography angiography (CCTA) was performed to evaluate the patency rate of the sequential venous grafts. The venous patency rate was evaluated by the FitzGibbon classification system[18]. FitzGibbon-A refers to a wide range of unobstructed grafts or less than 50% narrow grafts; FitzGibbon-B is a limited flow graft with a narrowing higher than 50%. FitzGibbon-O refers to an occlusive graft without blood flow. In this study, FitzGibbon-A/B was used for patency, and FitzGibbon-O was used for graft failure. The diseased graft was also regarded as a lesion if the lesion was located at the proximal/distal anastomosis site or the graft trunk.

Evaluation of Clinical Outcomes

First, the incidence of postoperative complications, such as atrial fibrillation, acute kidney injury, and reoperation, was compared between the two groups. In addition, leg wound complications 3 months after the operation and the occurrence of MACCEs 1 year after the operation were evaluated.

Statistical Analysis

SPSS 22.0 for Mac (IBM SPSS Statistics) was used for statistical analyses. Continuous variables are reported as the mean +/− standard deviation or median (interquartile range) (IQR). Categorical variables were reported as the absolute frequency and as a percentage. Student's *t*-test was applied for continuous data with equal or unequal variances. The Mann-Whitney U test was applied for continuous data that were not normally distributed. Pearson's *2* and Fisher's exact tests were used for categorical data. Statistical significance was accepted at p 0.05.

Results

One year CCTA results

There was no significant difference in the patency rates of the sequential vein grafts, internal mammary artery grafts or total grafts between the two groups one year after the operation. (before matching: sequential vein grafting, NT: 7.1% (10/141) vs CON: 11.5% (38/331), $p = 0.149$; internal mammary artery grafting, NT: 1.5% (2/136) vs CON: 3.8% (12/317), $p = 0.313$; total grafting, NT: 4.7% (13/277) vs CON: 7.7% (50/648), $p = 0.095$; after matching: sequential vein grafting, NT: 7.1% (10/140) vs CON: 7.3% (9/124), $p = 0.971$; internal mammary artery grafting, NT: 1.5% (2/135) vs CON: 2.6% (3/117), $p = 0.666$; total grafting, NT: 7.4% (13/275) vs CON:

5.0% (12/241), $p = 0.299$). In addition, the patency rates of the left anterior descending branch (LAD), left circumflex branch (LCX) and right coronary artery (RCA) territories were not significantly different between the two groups, as shown in Table 2.

Table 2
1-Year CCTA Patency Rates of the Grafts and the Coronary Artery Territories

	All study Patients			Propensity-Matched Patients		
Grafts	Group NT (n = 150)	Group CON (n = 355)	P value	Group NT (n = 148)	Group CON (n = 148)	P value
1-year patency	n = 141	n = 331		n = 140	n = 124	
Overall	4.7(13/277)	7.7(50/648)	0.095	7.4(13/275)	5.0(12/241)	0.299
Left ITA	1.5(2/136)	3.8(12/317)	0.313	1.5(2/135)	2.6(3/117)	0.666
Saphenous vein	7.1(10/141)	11.5(38/331)	0.149	7.1(10/140)	7.3(9/124)	0.971
LAD territory	1.7(3/176)	3.5(17/488)	0.309	1.1(2/174)	1.2(2/165)	1.000
LCX territory	1.5(2/132)	2.6(7/273)	0.755	1.5(2/132)	1.9(2/103)	1.000
RCA territory	6.0(9/151)	10.5(35/333)	0.107	6.0(9/149)	7.6(10/131)	0.597
Values are % (n/N).						
CCTA: Cardiac computed tomography angiography; ITA: Internal thoracic artery;LAD: Left anterior descending branch; LCX: Left circumflex branch; RCA: Right coronary artery.						

Early Clinical Hospital Outcomes

There was no difference in atrial fibrillation, acute kidney injury, reoperation or intra-aortic balloon pump (IABP) implantation between the two groups. Before matching, there were differences in the number of blood transfusions (NT: 15 (10.0%) vs CON: 98 (27.6%), $p < 0.001$), ventilation time (NT: 17.0 (13.0, 21.6) vs CON: 19.0 (15.0, 27.0), $p < 0.001$), and intensive care unit (ICU) stay (NT: 25.1 (20.0, 42.0) vs CON: 34.1 (22.0, 50.2), $p < 0.001$). After matching, there was no difference in ventilator time (NT: 17.0 (12.9, 21.4) vs CON: 17.0 (14.0, 20.4), $p = 0.398$) or ICU stay (NT: 24.4 (20.0, 42.0) vs CON: 23.0 (20.2, 39.7), $p = 0.693$). However, differences remained in the number of blood transfusions between the two groups (NT: 15 (10.1%) vs CON: 37 (25.0%), $p = 0.001$), as shown in Table 3.

Table 3
Comparison of Early Results in Hospital

Variables	All Study Patients			Propensity-Matched Patients		
	Group NT (n = 150)	Group CON (355)	P value	Group NT (148)	Group CON (n = 148)	P value
Atrial fibrillation, n (%)	44(29.3)	99(27.9)	0.742	43(29.1)	49(33.1)	0.451
Acute kidney injury, n (%)	10(6.7)	40(11.3)	0.114	10(6.8)	15(10.1)	0.296
Reoperation, n (%)	2(1.3)	8(2.3)	0.742	2(1.4)	3(2.0)	0.652
IABP implantation, n (%)	10(6.7)	23(6.5)	0.938	10(6.8)	5(3.4)	0.185
Blood transfusion, n (%)	15(10.0)	98(27.6)	<0.001	15(10.1)	37(25.0)	0.001
Ventilation time (h), median (IQR)	17.0(13.0,21.6)	19(15.0,27.0)	<0.001	17.0(12.9,21.4)	17.0(14.0,20.4)	0.398
ICU stay (h), median (IQR)	25.1(20.0,42.0)	34.1(22.0,50.2)	<0.001	24.4(20.0,42.0)	23.0(20.2,39.7)	0.693

IABP: Intra-aortic balloon pump; IQR: Interquartile range; ICU: Intensive care unit.

Main Clinical 1-year Outcomes

There was no significant difference in the composite clinical end points between the two groups before matching (NT: 3 (2.3%) vs CON: 9 (2.8%), $p = 1.000$) or after matching (NT: 3 (2.3%) vs CON: 3 (2.5%), $p = 1.000$). However, there were differences in leg wound complications 3 months after the operation between the two groups, both before (NT: 9 (6.9%) vs CON: 6 (1.9%), $p = 0.007$) and after matching (NT: 9 (6.9%) vs CON: 2 (1.7%), $p = 0.043$), as shown in Table 4.

Table 4
Main Outcomes and Adverse Event at 1-Year

Variable	All study Patients			Propensity-Matched Patients		
	Group NT (n = 150)	Group CON (n = 355)	P value	Group NT (n = 148)	Group CON (n = 148)	P value
1-year outcomes	n = 130	n = 320		n = 130	n = 120	
Composite of MACCEs, n (%)	3(2.3)	9(2.8)	1.000	3(2.3)	3(2.5)	1.000
Death from any cause, n (%)	0(0)	2(0.6)	1.000	0(0)	1(0.8)	0.48
Myocardial infarction, n (%)	0(0)	1(0.3)	1.000	0(0)	0(0)	-
Stroke, n (%)	2(1.5)	6(1.9)	1.000	2(1.5)	2(1.7)	1.000
Repeat revascularization, n (%)	1(0.8)	0(0)	0.289	1(0.8)	0(0)	1.000
Leg wound complications, n (%)	9(6.9)	6(1.9)	0.007	9(6.9)	2(1.7)	0.043
MACCEs: Major adverse cardiac and cerebrovascular events.						

Discussion

This study retrospectively analysed the application of the no-touch technique in off-pump bypass surgery with sequential vein grafts. The results indicate that this method is safe and effective. We compared the patency rate and MACCEs for sequential vein grafts harvested by the NT technique and conventional technique one year after the operation. The results showed that there was no significant difference between the two groups, suggesting that the use of sequential vein grafts harvested by the NT technique in off-pump bypass is reasonable.

Our results suggest that NT technology is superior to conventional technology in terms of postoperative blood transfusion. This may be attributed to the fact that in the process of harvesting the great saphenous vein with NT technology, the bleeding of many small branches is bound by the surrounding pedicle tissue, reducing the bleeding volume of the venous graft. However, regarding leg wound complications 3 months after surgery, NT technology was disadvantageous compared with conventional technology. It is also easy to understand that some tissues, such as some small nutrient vessels and fat, are dissociated in the process of NT-based harvesting, which increases the duration of the leg wound healing process. Our findings are similar to those of previous studies. The incidence of poor wound healing after the NT technique is higher than that of the conventional great saphenous vein technique[9]. In some previous studies[19], a drainage tube was used in the wound of the great saphenous vein after the vein was harvested by NT technology. Their results indicate that there was no significant difference in the occurrence of wound complications after drainage tube placement between NT and conventional technology. This provides good guidance for the treatment of leg wounds after harvesting the great saphenous vein with NT technology.

Previous studies showed that the vein grafts obtained by NT technology were mostly single vein grafts, and the most common surgery was on-pump CABG[7, 9, 20, 21]. This is different from our study; we used all sequential vein grafts, and all procedures were off-pump CABG. Sequential vein grafts can preserve vein length, and off-pump bypass grafting can accelerate postoperative recovery and reduce the incidence of postoperative complications. In our study, there was no significant difference in the patency rate of sequential venous grafts between the two groups after 1 year of CCTA follow-up. In addition, there was no significant difference in the incidence of MACCEs between the two groups at the 1-year follow-up. This is basically consistent with previous studies. It has been proven that the application of sequential vein grafts harvested by NT technology in off-pump bypass surgery is safe and effective. Long-term differences between the two still need to be followed up in the future.

Our study is a retrospective study, which implies a certain selection bias. In addition, our follow-up time was not sufficiently long. In the Souza study, we can see that the advantages of NT technology are gradually reflected in the longer follow-up time. In the future, we will continue to follow the patients for 3 years, 5 years, 10 years or even longer. In addition, the selection of a larger sample size and use of prospective research should be implemented, which we will strive to achieve in the future.

With the increasing number of off-pump CABG procedures, the expectations for the long-term graft patency rate are increasing. The application of sequential venous grafts harvested by NT technology in off-pump CABG is worthy of exploration and may provide better surgical treatment for patients with coronary artery disease.

Conclusions

The application of the NT technique in off-pump CABG with sequential vein grafts is safe and effective. Leg wound complications are more common with the NT technique than with the conventional technique.

Abbreviations

SVG
Saphenous vein graft; NT:No touch technique; CON:Conventional technique; CABG:Coronary artery bypass grafting; MACCEs:Major adverse cardiac and cerebrovascular events; RA:Radial artery; BMI:Body mass index; PCI:Percutaneous coronary intervention; NYHA:New York Heart Association; CCTA:cardiac computed tomography angiography; IQR:Interquartile range; LAD:Left anterior descending branch; LCX:Left circumflex branch; RCA:Right coronary artery; IABP:Intra-aortic balloon pump; ICU:Intensive care unit.

Declarations

Ethics approval and consent to participate

The Ethics Committee of Beijing Anzhen Hospital and Capital Medical University (Approval Numbers:2018036X) approved the study. All participants signed informed consent forms.

Consent for Publication

Not applicable

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Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Conflicts of interest

It should be recognized that none of the authors have any financial or scientific conflicts of interest with regard to the research described in this manuscript.

Authors' contributions

Ran Dong and Jubing Zheng were responsible for the design, supervision of the study, and revision of the manuscript. Xuejian Hou drafted the manuscript. Zhuhui Huang and Kui Zhang designed a statistical plan. Yang Li and Taoshuai Liu participated in the revision of the manuscript and the coordination of the study. Yang Zhao and Bangrong Song participated in data acquisition. All authors read and agreed to the final manuscript.

References

1. Samano N, Bodin L, Karlsson J, Geijer H, Arbeus M, Souza D: **Graft patency is associated with higher health-related quality of life after coronary artery bypass surgery**. *Interact Cardiovasc Thorac Surg* 2017, **24**(3):388–394.
2. Johansson BL, Souza DS, Bodin L, Filbey D, Bojo L: **No touch vein harvesting technique for CABG improves the long-term clinical outcome**. *Scand Cardiovasc J* 2009, **43**(1):63–68.
3. Hlatky MA, Boothroyd DB, Reitz BA, Shilane DA, Baker LC, Go AS: **Adoption and effectiveness of internal mammary artery grafting in coronary artery bypass surgery among Medicare beneficiaries**. *J Am Coll Cardiol* 2014, **63**(1):33–39.
4. Tranbaugh RF, Dimitrova KR, Friedmann P, Geller CM, Harris LJ, Stelzer P, Cohen BM, Ko W, DeCastro H, Lucido D *et al*: **Coronary artery bypass grafting using the radial artery: clinical outcomes, patency, and need for reintervention**. *Circulation* 2012, **126**(11 Suppl 1):S170-175.
5. Gaudino M, Benedetto U, Fremes S, Biondi-Zoccai G, Sedrakyan A, Puskas JD, Angelini GD, Buxton B, Frati G, Hare DL *et al*: **Radial-Artery or Saphenous-Vein Grafts in Coronary-Artery Bypass Surgery**. *N Engl J Med*

2018, **378**(22):2069–2077.

6. Lopes RD, Mehta RH, Hafley GE, Williams JB, Mack MJ, Peterson ED, Allen KB, Harrington RA, Gibson CM, Califf RM *et al*: **Relationship Between Vein Graft Failure and Subsequent Clinical Outcomes After Coronary Artery Bypass Surgery**. *Circulation* 2012, **125**(6):749–756.
7. Souza DS, Johansson B, Bojo L, Karlsson R, Geijer H, Filbey D, Bodin L, 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 Thorac Cardiovasc Surg* 2006, **132**(2):373–378.
8. Samano N, Geijer H, Liden M, Fremes S, Bodin L, Souza D: **The no-touch saphenous vein for coronary artery bypass grafting maintains a patency, after 16 years, comparable to the left internal thoracic artery: A randomized trial**. *J Thorac Cardiovasc Surg* 2015, **150**(4):880–888.
9. Deb S, Singh SK, de Souza D, Chu MWA, Whitlock R, Meyer SR, Verma S, Jeppsson A, Al-Saleh A, Brady K *et al*: **SUPERIOR SVG: no touch saphenous harvesting to improve patency following coronary bypass grafting (a multi-Centre randomized control trial, NCT01047449)**. *Journal of Cardiothoracic Surgery* 2019, **14**(1).
10. Dreifaldt M, Mannion JD, Geijer H, Lidén M, Bodin L, Souza D: **The no-touch saphenous vein is an excellent alternative conduit to the radial artery 8 years after coronary artery bypass grafting: A randomized trial**. *The Journal of Thoracic and Cardiovascular Surgery* 2019.
11. Dreifaldt M, Mannion JD, Bodin L, Olsson H, Zagozdzon L, Souza D: **The no-touch saphenous vein as the preferred second conduit for coronary artery bypass grafting**. *Ann Thorac Surg* 2013, **96**(1):105–111.
12. Papakonstantinou NA, Baikoussis NG, Goudevenos J, Papadopoulos G, Apostolakis E: **Novel no touch technique of saphenous vein harvesting: Is great graft patency rate provided?** *Ann Card Anaesth* 2016, **19**(3):481–488.
13. Kopjar T, Dashwood MR, Dreifaldt M, de Souza DR: **No-touch saphenous vein as an important conduit of choice in coronary bypass surgery**. *J Thorac Dis* 2018, **10**(Suppl 26):S3292-S3296.
14. Byrne JG, Leacche M: **Off-Pump CABG Surgery "No-Touch" Technique to Reduce Adverse Neurological Outcomes**. *J Am Coll Cardiol* 2017, **69**(8):937–938.
15. Al-Ruzzeh S, George S, Bustami M, Nakamura K, Khan S, Yacoub M, Amrani M: **The early clinical and angiographic outcome of sequential coronary artery bypass grafting with the off-pump technique**. *J Thorac Cardiovasc Surg* 2002, **123**(3):525–530.
16. Ji Q, Song K, Xia L, Shi Y, Ma R, Shen J, Ding W, Wang C: **Sequential Saphenous Vein Coronary Bypass Grafting**. *Int Heart J* 2018, **59**(6):1211–1218.
17. Park SJ, Kim HJ, Kim JB, Jung SH, Choo SJ, Lee JW, Chung CH: **Sequential Versus Individual Saphenous Vein Grafting During Coronary Arterial Bypass Surgery**. *Ann Thorac Surg* 2019.
18. Fitzgibbon GM, Kafka HP, Leach AJ, Keon WJ, Hooper GD, Burton JR: **Coronary bypass graft fate and patient outcome: Angiographic follow-up of 5,065 grafts related to survival and reoperation in 1,388 patients during 25 years**. *Journal of the American College of Cardiology* 1996, **28**(3):616–626.
19. Kim YH, Oh HC, Choi JW, Hwang HY, Kim KB: **No-Touch Saphenous Vein Harvesting May Improve Further the Patency of Saphenous Vein Composite Grafts: Early Outcomes and 1-Year Angiographic Results**. *Ann Thorac Surg* 2017, **103**(5):1489–1497.

20. Samano N, Geijer H, Bodin L, Arbeus M, Mannion JD, Dashwood M, Souza D: **The no-touch saphenous vein graft in elderly coronary bypass patients with multiple comorbidities is a promising conduit to substitute the left internal thoracic artery**. *J Thorac Cardiovasc Surg* 2017, **154**(2):457–466 e453.
21. Janiec M, Friberg O, Thelin S: **Long-term clinical outcomes after coronary artery bypass grafting with pedicled saphenous vein grafts**. *J Cardiothorac Surg* 2018, **13**(1):122.

Figures

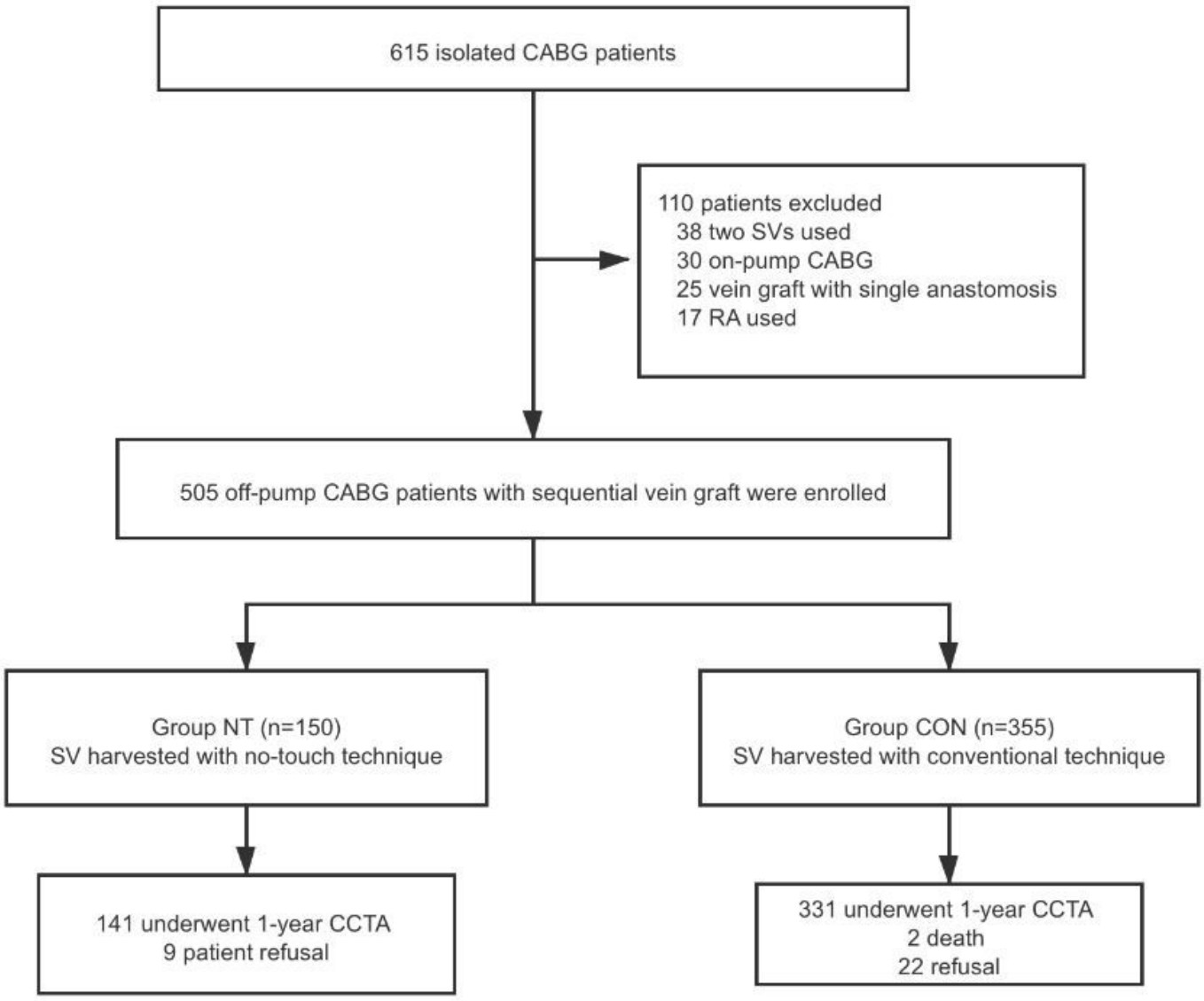

Figure 1

Summary flow diagram of enrolled patients. (CABG: coronary artery bypass graft; SV: saphenous vein; RA: radial artery; CCTA: cardiac computed tomography angiography; NT: no touch technique; CON: conventional technique)