

A Single Center Experience with Coronary Endarterectomy and Vein Patch Reconstruction

C. F. Hynes¹, G. T. Trachiotis^{1,2*}

¹Division of Cardiothoracic Surgery, Veterans Affairs Medical Center, Washington DC, USA

²Division of Cardiothoracic Surgery, The George Washington University, Washington DC, USA

Email: *gregory.trachiotis@va.gov

Received 12 January 2015; accepted 31 January 2015; published 3 February 2015

Copyright © 2015 by authors and Scientific Research Publishing Inc.

This work is licensed under the Creative Commons Attribution International License (CC BY).

<http://creativecommons.org/licenses/by/4.0/>



Open Access

Abstract

Background: To evaluate the medium and late term outcomes of coronary artery bypass grafting with pull-through coronary endarterectomy using a saphenous vein patch for bypass distal anastomosis site. **Methods:** Retrospective review of all coronary artery bypass graft (CABG) procedures performed from January 1, 2000 through June 30, 2013 with and without concomitant coronary endarterectomy (CE), was carried out at the Veterans Affairs Medical Center in Washington DC. Patients who underwent concomitant valve operations were excluded. Primary outcome was overall survival, with analyses performed examining CE as well as the use of cardiopulmonary bypass. Secondary outcomes included 30-day mortality and post-operative MI. **Results:** 1255 CABG operations were performed, 10 of which included CE. All CE procedures were performed with saphenous vein patch. 7 involved left anterior descending artery (LAD) CE with left internal mammary artery (LIMA) conduits. The remaining 3 were diagonal branch artery (D1) CE with saphenous vein bypass conduits. 1-year survival was 70%. 5-year survival was 43% out of 7 patients. **Conclusions:** Pull-through CE with saphenous vein patch is a safe alternative technique for patients with diffuse coronary artery disease. Perioperative events and intermediate outcomes are favorable, although long-term survival is less than patients without CE.

Keywords

Coronary Endarterectomy, Off-Pump Coronary Artery Bypass Grafting, Saphenous Vein Patch

1. Introduction

Coronary endarterectomy (CE) is primarily used as an adjunct to coronary artery bypass grafting (CABG) in pa-

*Corresponding author.

How to cite this paper: Hynes, C.F. and Trachiotis, G.T. (2015) A Single Center Experience with Coronary Endarterectomy and Vein Patch Reconstruction. *World Journal of Cardiovascular Surgery*, 5, 11-17.
<http://dx.doi.org/10.4236/wjcs.2015.52003>

tients with diffuse coronary atherosclerotic disease to create an adequate site for distal anastomosis. Decreased survival after CE has prevented its routine use [1]; however, cases of diffuse arterial disease require CE to create a patent vessel for distal anastomosis and flow. More recent studies have demonstrated improvement of survival and patency with advancements in technique and post-operative medical therapy [2]. Several techniques have emerged as feasible and safe options, though the question remains as to which, if any, can improve survival patency and postoperative complications. This review is aimed at presenting our experience using a vein patch at the endarterectomy site as a landing site for distal bypass conduit anastomosis.

2. Methods

Retrospective review of all coronary artery bypass graft (CABG) procedures performed from January 1, 2000 through June 30, 2013 was carried out at the Veterans Affairs Medical Center in Washington DC. Data was prospectively captured and registered in the national VA databases system (CISCP/VASQUIP), and this review was approved by the Washington DC VAMC IRB. Patients who underwent concomitant valve operations were excluded. All coronary endarterectomy (CE) procedures were performed by a single surgeon. Primary outcome was overall survival, comparing CABG alone versus CABG with coronary endarterectomy (CE). Secondary outcomes evaluated were 30-day mortality and post-operative MI. Univariate analysis of pre-operative and intra-operative characteristics was performed using t-test for continuous variables and chi-squared analysis for proportions. Kaplan-Meier analysis was used to compare off-pump CABG with CE to off-pump CABG alone.

Coronary endarterectomy (CE) was employed in patients with diffuse atherosclerotic disease lacking an adequate site for bypass conduit distal anastomosis seen on pre-operative angiography or intra-operative assessment, and principally focused on the left anterior descending (LAD) artery. The identified coronary artery was stabilized with a Medtronic Octopus Evolution system (Medtronic, Inc., Minneapolis, MN) on the beating heart. Proximal and distal vessel control was obtained with a silastic vessel loop placed under the coronary artery (non-circumferential). Arteriotomy was performed with a micro blade to ensure luminal entry. Retraction was gently placed on the vessel loops to limit coronary flow. Endarterectomy ball and spatula probes were used to free plaques proximally and distally and then the full plaques extracted (Figure 1) by pull-through technique in both directions. Multiple or skip arteriotomies were not used. A saphenous vein (SV) patch was sewn over the endarterectomy site using 7-0 prolene. The LIMA graft was sewn end-to-side on the SV patch with 7-0 prolene, fine needle point. The anastomosis was de-aired, vessel loops released, and the anastomosis flow was confirmed with intra-operative duplex VeriQ system (MediStim, Inc., Plymouth, MN) was used to verify adequate transit time flow measurement, doppler velocity measurements and real-time sonography within the bypass conduits in all cases. When a LIMA was not used the technique was similar for an SV conduit. All CE patients were started on dual antiplatelet therapy consisting of a 650 mg aspirin suppository within two hours to arrival to the ICU, aspirin 81 mg with clopidogrel 75 mg per day on postoperative day 1, and maintained for one year or life-long [3].



Figure 1. Endarterectomy plaque specimen from diffusely atherosclerotic LAD coronary artery, measuring 8 cm.

3. Results

During the 12.5-year period, 1255 CABG operations were performed at our institution, excluding those with concomitant valve operations. 798 (64%) of cases were off-pump coronary bypasses (OPCAB). 10 cases included CE, and 8 of these were OPCAB. Pre-operative characteristics including age, sex, body surface area, common comorbidities and functional status were not significantly different (**Table 1**). Pre-operative cardiac catheterization measurements of pulmonary artery systolic pressures (PASP) and aortic systolic pressures (AOSP) were also similar. Average number of coronary bypass grafts were 2.5 ± 0.7 in the CE group and 2.2 ± 0.8 in the non-CE group ($P = 0.23$).

Among the 10 patients receiving CE, 7 cases used a left internal mammary artery (LIMA) conduit to left anterior descending artery endarterectomy site with saphenous vein patch. The other 3 cases utilized a saphenous vein bypass conduit to first diagonal branch artery endarterectomy site with a separate vein segment used for the patch (**Table 2**). 1-year survival rate was 70%. 5-year survival was 43% out of 7 patients. Four patients are still living at a follow up of 8.3, 3.7, 3.5, 2.1 years.

Rate of post-operative MI, stroke, kidney injury and cardiac arrest were zero in the CE group, though the difference did not reach statistical significance in comparison to non-CE patients (**Table 3**). One CE patient died within 30 days from complications of bowel ischemia, which was a significantly higher rate than non-CE CABG ($P = 0.03$).

Kaplan-Meier survival analysis found mean survival of all CE patients is 5.3 years compared with 8.9 years for non-CE CABG patients. Mean survival of OPCAB with CE is 4.4 years and 8.1 years for OPCAB patients without CE (**Figure 2**). Log rank analysis demonstrated significance for each comparison ($P = 0.02$ and 0.008 , respectively).

Table 1. Pre-operative and operative characteristics.

Variable	CE (n = 10)	Without CE (n = 1245)	P-value
Age	64.5 \pm 7.9	64.6 \pm 9.5	0.97 (NS)
BSA	2.1 \pm 0.2	2.0 \pm 0.2	0.26 (NS)
Weight (lbs.)	208 \pm 34.2	195.6 \pm 40.4	0.28 (NS)
COPD	20% (2)	45% (561)	0.11 (NS)
Diabetes	50% (5)	40% (494)	0.46 (NS)
Hypertension	100% (10)	90% (1120)	0.50 (NS)
Prior MI			
>7 days preop	50% (5)	43.5% (541)	0.42
\leq 7 days preop	20% (2)	9.8% (122)	(NS)
Current smoking	30% (3)	31.2% (388)	0.94 (NS)
NYHA class III or IV	30% (3)	46.7% (582)	0.44 (NS)
CCS class III or IV	60% (6)	76.4% (951)	0.23 (NS)
Functional dependence	10% (1)	18.4% (229)	0.50 (NS)
Prior heart surgery	0	1.9% (24)	0.66 (NS)
PASP	40.2 \pm 11.8	35.9 \pm 11.4	0.52 (NS)
AOSP	137.5 \pm 25.7	136.6 \pm 25.5	0.92 (NS)
ASA > 3	90% (9)	74% (926)	0.26 (NS)
Number of bypass grafts	2.5 \pm 0.7	2.2 \pm 0.8	0.23 (NS)
Off-pump CABG	80% (8)	63.5% (790)	0.28 (NS)
Emergency	0	1.5% (19)	0.69 (NS)

Table 2. CE cohort characteristics.

Variable	CE (n = 10)
Off-pump	80%
CE vessel	
LAD	70%
Diagonal branch	30%
Graft to CE vessel	
Left IMA	70%
Greater saphenous vein	30%
30 day mortality	10%
1-year survival	70%
5-year survival	43% (3 of 7)

Table 3. Complication rates.

Variable	CE (n = 10)	Without CE (n = 1245)	P-value
MI	0	0.6% (7)	0.81 (NS)
Renal failure	0	0.6% (7)	0.81 (NS)
Mediastinitis	0	0.7% (9)	0.79 (NS)
Cardiac arrest	0	2.0% (25)	0.65 (NS)
Re-operation for hemorrhage	0	1.8% (22)	0.67 (NS)
Re-intubation within 30 days	10% (1)	2.3% (29)	0.24 (NS)
Tracheostomy requirement	0	0.6% (7)	0.81 (NS)
Stroke	0	0.4% (5)	0.84 (NS)
30 day mortality	10% (1)	1.4% (18)	0.03*

*Indicates statistical significance. NS = not significant.

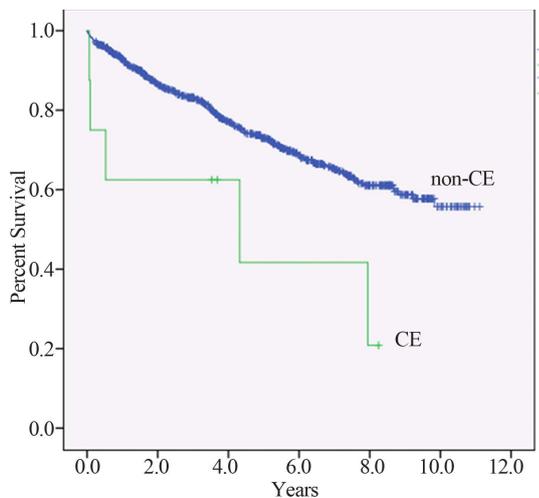


Figure 2. Kaplan-Meier survival analysis comparing OPCAB with and without CE.

4. Comment

Innovations in CE technique have improved coronary revascularization outcomes [2]. Despite current reports of greater 30-day mortality and post-operative MI after CABG with CE compared to CABG only [4], many decisions surrounding operative and postoperative management have been found to impact outcomes. A major focus of surgical improvement is the enhanced local thrombogenicity incited by exposed collagen after extensive disruption of the tunica intima. Efforts made to address this issue include augmentation of arterial diameter with conduit on-lay patch, free vein patch reconstruction at distal anastomosis site, use of a closed “pull-through” endarterectomy technique, and post-operative antiplatelet and anticoagulation regimens.

Relying chiefly on retrospective studies, a few trends have been identified regarding CE technique. A comparison of long arteriotomy with open CE and anastomosis to onlay vein or arterial patch technique versus closed pull-through CE with anastomosis of conduit directly to coronary arteriotomy found improved graft patency in the former [5]. This raises the question of whether patency improved due to the CE technique or the patch reconstruction. Others have reported higher rates of 30-day mortality, post-operative MI and ventricular arrhythmias after anastomosis directly to the arteriotomy compared with either onlay or free patch at the distal anastomosis [6] [7], which supports the likelihood that the reconstruction impacts outcomes.

Although valid concerns have been raised regarding the possibility that pull-through technique may not adequately endarterectomize branch vessel ostia [8], we address this so-called “snow-plow effect” in two ways. First, intra-operative duplex ultrasound verifies appropriate blood flow and velocity. Furthermore, when any concern for incomplete endarterectomy arises due to poor plaque tapering or obstruction preventing passage of the vessel probe, the arteriotomy is extended.

Arterial conduits to endarterectomized targets, including internal mammary and radial arteries, have been reported to provide significantly greater 7-year survival and patency than vein conduits [9]. In addition to various methods of CE vessel reconstruction and grafting, endarterectomy has been successfully applied to OPCAB cases with similar rates of morbidity and mortality [10]-[12]. The pull through CE technique may benefit efficiency in OPCAB cases without compromising patency or survival if a vein patch is included.

The predominant target vessel in our cohort was the LAD. Although there has been some disagreement in the literature, most recent studies have found that CE of LAD arteries have comparable if not better outcomes than RCA or circumflex procedures [1] [7]. This may be due to the improved revascularization of the LAD territory having a greater impact on cardiac output via the left ventricle.

The use of vein patch at the distal anastomosis provides adequate coverage of the arteriotomy when the availability of bypass conduit and length are constraints. In addition, vein patch reconstruction of LAD compared to LIMA onlay has been found to have equal or lower operative mortality and perioperative MI, as well as comparable actuarial survival rates at 5 and 10 years [2].

Reports of early post-operative mortality range from 2.7% - 11% [6] [13]. Evidence indicates LAD endarterectomy patients have lower 30-day mortality than RCA or circumflex CE [1]. Furthermore, better survival can be achieved when the number of CE vessels is limited to one vessel [11] [14]. Our cohort falls into this range with 30-day mortality at 10%.

Advancements in medical and endovascular management of CAD have shifted the population of patients undergoing surgical revascularization to one of more severe disease. 5-year survival rates have been reported to range from 71% - 92% [15]. Limited data has been published regarding longer term outcomes. Actuarial data for 10-year survival has been reported at 74% - 78% [15] [16]. In a systematic review of CE with OPCAB, survival outcomes were not significantly different from those using CPB [17].

Several studies have found those patients with diffuse disease to have greater rates of previous MI, chronic kidney disease and decreased LV function [16] [18]. Though ours did not identify different rates of comorbidities, clearly patients undergoing CE have worse localized atherosclerosis than those who do not require it, and therefore the validity of direct comparison is limited. Although survival was worse in our CE group, three survived 8 years or more, and three others are still living without recurrence of MI. Moreover, post-operative complications were few, with one re-intubation for respiratory distress and one 30-day mortality related to bowel ischemia.

Our goal was complete revascularization, especially to the LAD territory. Thus the negative impact of survival in the CE group, although small in sample size, could be related to the diffuse nature of the coronary artery disease and extent of disease pattern. It is recognized that poor targets and diffuse CAD at the time of revascularization are known to impact long-term survival [19].

5. Conclusion

This review is limited by small sample size. Also, although immediate operative graft assessment was performed, the impact of graft patency at one year or beyond was not assessed angiographically. Nonetheless, surviving patients were symptom free with no recurrent events. Our method of CE reconstruction using vein patch for conduit anastomosis is a safe and effective alternative to current methods of CE, especially facilitating revascularization to the LAD territory providing satisfactory perioperative and intermediate outcomes in our veteran population.

References

- [1] Sundt, T.M., Camillo, C.J., Mendeloff, E.N., Barner, H.B. and Gay, W.A. (1999) Reappraisal of Coronary Endarterectomy for the Treatment of Diffuse Coronary Artery Disease. *Annals of Thoracic Surgery*, **68**, 1272-1277. [http://dx.doi.org/10.1016/S0003-4975\(99\)00693-1](http://dx.doi.org/10.1016/S0003-4975(99)00693-1)
- [2] Myers, P.O., Tabata, M., Shekar, P.S., Couper, G.S., Khalpey, Z.I. and Aranki, S.F. (2012) Extensive Endarterectomy and Reconstruction of the Left Anterior Descending Artery: Early and Late Outcomes. *Journal of Thoracic and Cardiovascular Surgery*, **143**, 1336-1340. <http://dx.doi.org/10.1016/j.jtcvs.2011.08.058>
- [3] Trachiotis, G.D. (2010) Early Antiplatelet Therapy in Coronary Artery Bypass Grafting: A Calculated Benefit. *Innovations (Philadelphia)*, **5**, 317-325. <http://dx.doi.org/10.1097/IMI.0b013e3181f63b30>
- [4] Soylu, E., Harling, L., Ashrafian, H., Casula, R., Kokotsakis, J. and Athanasiou, T. (2014) Adjunct Coronary Endarterectomy Increases Myocardial Infarction and Early Mortality after Coronary Artery Bypass Grafting: A Meta-Analysis. *Interactive Cardiovascular and Thoracic Surgery*, **19**, 462-473. <http://dx.doi.org/10.1093/icvts/ivu157>
- [5] Nishi, H., Miyamoto, S., Takanashi, S., Minamimura, H., Ishikawa, T., Kato, Y. and Shimizu, Y. (2005) Optimal Method of Coronary Endarterectomy for Diffusely Diseased Coronary Arteries. *Annals of Thoracic Surgery*, **79**, 846-853. <http://dx.doi.org/10.1016/j.athoracsur.2004.06.070>
- [6] Gol, M.K., Yilmazkaya, B., Goksel, S., Sener, E., Mavitas, B., Tasdemir, O. and Bayazit, K. (1999) Results of Right Coronary Artery Endarterectomy with or without Patchplasty. *Journal of Cardiac Surgery*, **14**, 75-81. <http://dx.doi.org/10.1111/j.1540-8191.1999.tb00954.x>
- [7] Soylu, E., Harling, L., Ashrafian, H. and Athanasiou, T. (2014) Does Coronary Endarterectomy Technique Affect Surgical Outcome When Combined with Coronary Artery Bypass Grafting? *Interactive Cardiovascular and Thoracic Surgery*, **19**, 848-855. <http://dx.doi.org/10.1093/icvts/ivu261>
- [8] Nishigawa, K., Fukui, T. and Takanashi, S. (2014) Coronary Endarterectomy for the Diffusely Diseased Coronary Artery. *General Thoracic and Cardiovascular Surgery*, **62**, 461-467. <http://dx.doi.org/10.1007/s11748-014-0414-x>
- [9] Schwann, T.A., Zacharias, A., Riordan, C.J., Durham, S.J., Shah, A.S. and Habib, R.H. (2007) Survival and Graft Patency after Coronary Artery Bypass Grafting with Coronary Endarterectomy: Role of Arterial versus Vein Conduits. *Annals of Thoracic Surgery*, **84**, 25-31. <http://dx.doi.org/10.1016/j.athoracsur.2007.02.053>
- [10] Hussain, I., Ghaffar, A., Shahbaz, A., Sami, W., Muhammad, A., Seher, N., et al. (2008) In Hospital Outcome of Patients Undergoing Coronary Endarterectomy: Comparison between Off-Pump vs On-Pump CABG. *Journal of Applied Mathematics and Computing*, **20**, 31-37.
- [11] Takahashi, M., Gohil, T.B., Lento, P., Filsoufi, F. and Reddy, R. (2012) Early and Mid-Term Results of Off-Pump Endarterectomy of the Left Anterior Descending Artery. *Interactive Cardiovascular and Thoracic Surgery*, **16**, 301-306. <http://dx.doi.org/10.1093/icvts/ivs482>
- [12] Naseri, E., Sevinc, M. and Erk, M.K. (2003) Comparison of Off-Pump and Conventional Coronary Endarterectomy. *Heart Surgery Forum*, **6**, L216-L219.
- [13] Kato, Y., Shibata, T., Takanashi, S., Fukui, T., Ito, A. and Shimizu, Y. (2012) Results of Long Segmental Reconstruction of Left Anterior Descending Artery Using Left Internal Thoracic Artery. *Annals of Thoracic Surgery*, **93**, 1195-1200. <http://dx.doi.org/10.1016/j.athoracsur.2011.12.059>
- [14] Christenson, J.T., Simonet, F. and Schmuzigar, M. (1995) Extensive Endarterectomy of the Left Anterior Descending Coronary Artery Combined with Coronary Artery Bypass Grafting. *Coronary Artery Disease*, **6**, 731-737.
- [15] Vohra, H.A., Kanwar, R., Khan, T. and Dimitri, W.R. (2006) Early and Late Outcome after Off-Pump Coronary Artery Bypass Graft Surgery with Coronary Endarterectomy: A Single-Center 10-Year Experience. *Annals of Thoracic Surgery*, **81**, 1691-1696. <http://dx.doi.org/10.1016/j.athoracsur.2005.12.028>
- [16] Sirivella, S., Gielchinsky, I. and Parsonnet, V. (2005) Results of Coronary Artery Endarterectomy and Coronary Artery Bypass Grafting for Diffuse Coronary Artery Disease. *Annals of Thoracic Surgery*, **80**, 1738-1745. <http://dx.doi.org/10.1016/j.athoracsur.2005.05.034>

- [17] Soylu, E., Harling, L., Ashrafian, H. and Athanasiou, T. (2014) Should We Consider Off-Pump Coronary Artery Bypass Grafting in Patients Undergoing Coronary Endarterectomy? *Interactive CardioVascular and Thoracic Surgery*, **19**, 295-301. <http://dx.doi.org/10.1093/icvts/ivu116>
- [18] Tiruvoipati, R., Loubani, M., Lencioni, M., Ghosh, S., Jones, P. and Patel, R. (2005) Coronary Endarterectomy: Impact on Morbidity and Mortality When Combined with Coronary Artery Bypass Surgery. *Annals of Thoracic Surgery*, **79**, 1999-2003. <http://dx.doi.org/10.1016/j.athoracsur.2004.12.041>
- [19] Trachiotis, G.D., Weintraub, W.S., Johnston, T.S., Jones, E.L., Guyton, R.A. and Craver, J.M. (1998) Coronary Artery Bypass Grafting in Patients with Advanced Left Ventricular Dysfunction. *Annals of Thoracic Surgery*, **66**, 1632-1639. [http://dx.doi.org/10.1016/S0003-4975\(98\)00773-5](http://dx.doi.org/10.1016/S0003-4975(98)00773-5)

Scientific Research Publishing (SCIRP) is one of the largest Open Access journal publishers. It is currently publishing more than 200 open access, online, peer-reviewed journals covering a wide range of academic disciplines. SCIRP serves the worldwide academic communities and contributes to the progress and application of science with its publication.

Other selected journals from SCIRP are listed as below. Submit your manuscript to us via either submit@scirp.org or **Online Submission Portal**.

