

Outcomes of Off-Pump Coronary Artery Bypass with Coronary Endarterectomy in Advanced Diffuse Atherosclerotic Coronary Artery Disease

Chusak Nudaeng, MD

Thammavit Soonthornrak, MD

*Cardiovascular Thoracic Surgery Unit, Department of Surgery, Rajavithi Hospital,
Rangsit University, Bangkok, Thailand*

Abstract

Introduction: Coronary endarterectomy (CE) is an optional treatment modality for advanced diffuse atherosclerotic coronary artery disease (CAD) to complement complete surgical revascularization. This strategy is still debatable in the existing guidelines, particularly in off-pump coronary artery bypass (OPCAB) surgery. We present a single-center's experience with this technique.

Methods: We conducted a retrospective analysis in 17 patients who underwent OPCAB surgery with coronary endarterectomy (CE) from January 2013 to December 2017. The aim of study was to determine the 30-day mortality and complications with this technique.

Results: This study included 17 patients (15 men and 2 women with mean age 58.9 ± 7.7 years). Sixteen of 17 patients (94%) underwent closed endarterectomy and one patient underwent open endarterectomy. There were no deaths observed during the 30-day postoperative period, but one late death (at 6 months after operation) due to multiple organ failure. Three patients (18%) developed post-operative atrial fibrillation (POAF) and 2 patients (12%) had hospital acquired pneumonia. The mean hospital stay was 12 days (range, 8 to 40 days).

Conclusion: Advanced diffuse CAD is still a challenging condition to treat and OPCAB with CE can be a safe and effective option with low mortality and acceptable complications under experienced hands. However, long-term clinical follow-up and post-operative angiographic evaluation are still required.

Keywords: Coronary endarterectomy, Off-pump coronary artery bypass, Diffuse atherosclerosis

INTRODUCTION

The ideal goal of atherosclerotic coronary artery disease (CAD) treatment is to achieve complete myocardial revascularization.¹⁻³ Coronary endarterectomy (CE) is one possible treatment option. Coronary endarterectomy, introduced by Bailey and colleagues, has been used to treat severely or diffusely diseased coronary arteries since the 1950s.⁴ Early studies on

CE showed unacceptable perioperative morbidity and mortality which discouraged its application.⁵⁻⁷ Recent studies showed improvement in outcomes because of recently available knowledge of CAD pathophysiology and greater experience with a larger number of severe diffuse and multiple CAD patients as well as improvements in technology.⁸⁻⁹ In more recent literature, CE is still controversial as a treatment option, especially in

Received for publication 28 October 2020; Revised 10 January 2021; Accepted 13 January 2021

Correspondence address: Chusak Nudaeng, MD, Cardiovascular Thoracic Surgery Unit, Department of Surgery, Rajavithi Hospital, 2 Phayathai Road, Rat-chathewi, Bangkok 10400, Thailand; Telephone: +66 61 919 1554; Email: bae_ps@yahoo.com

OPCAB.¹⁰⁻¹⁴ The aim of the present study is to determine the outcomes of OPCAB with CE in our hospital.

METHODS

A total of 367 patients with CAD underwent OPCAB in our hospital between January, 2013 to December, 2017. This study included 17 patients who underwent OPCAB with coronary endarterectomy. The study was approved by the hospital's institutional ethics committee (228/2561).

All 17 patients underwent OPCAB with full median sternotomy. Prophylactic intra-aortic balloon pump (IABP) was used in patients with poor left ventricular ejection fraction (LVEF < 30%), critical left main disease (LM) (stenosis > 70%) or LM equivalence. The CE procedure was usually planned before operation when angiography showed long, diffuse, coronary plaques at the target vessels. The decision to do a CE procedure could also be determined intraoperatively, after coronary arteriotomy shows severe coronary plaque stenosis.

CE was performed using either the closed technique (small arteriotomy with gentle traction to remove most of the intracoronary material), performed in most cases, or the open technique (longer arteriotomy that allows the full-length lesion to be visualized). The choice depended on which approach would result in least possible endothelial trauma for a given patient. At first, only a small incision was made on the vessel, which is standard for coronary artery bypass grafting. After evaluating the anatomy of a particular artery, the incision was extended slightly. Further extension of the incision was made if by gentle pulling of the plaque its removal was unsuccessful. A small surgical spatula was used with caution to help separate the plaque from the vessel wall. Completeness of each endarterectomy was evaluated using a surgical probe of diameter adjusted to the current vessel. The whole procedure was performed by the same surgeon (Figure 1).

After an uneventful operation, the patient received

325 mg of aspirin within 4 hours after surgery followed by dual anti-platelet therapy for 1 year and 100-160 mg aspirin daily thereafter. Intravenous heparin was given only to patients while on IABP, to achieve activated clotting time (ACT) of 150-200 seconds.

All patients were scheduled for follow-up clinical and laboratory evaluation. Important cardiac-related events such as death, myocardial infarction, repeat PCI or cardiac surgery and cerebrovascular episodes of short-term to mid-term duration (average, 28 ± 15 months) were recorded. Transthoracic echocardiogram was performed in all 17 patients, immediately after surgery, during hospital admission and annually, to evaluate new loss of viable myocardium or new regional wall motion abnormality. Due to the presence of chronic kidney disease in most patients (77% of all patients) in the present study, postoperative angiography was not performed.

SPSS (SPSS Inc., Chicago, IL, USA) version 20.0 statistical software was used for all the analyses.

RESULTS

There were 17 patients in the present study, of whom 88% were men. The mean age of patients was 58.9 ± 7.7 years, with poor LVEF (< 30%) in 24%, presence of DM 59% and renal insufficiency in 77% of patients (Table 1).

Most patients were emergency and urgent cases (Table 2). Thirteen of 17 patients (77%) underwent 3 anastomoses. Closed technique was performed in 94% of patients. Target vessels are shown in Table 2; that with the highest frequency was LAD at 77%. No patient was converted to on-pump.

There was no hospital mortality, defined as death within 30 days of surgery. One patient died from multiple organ failure at 6 months after surgery. There were no re-interventions. The most common postoperative complication was atrial fibrillation (18%). There was no occurrence of stroke. Other postoperative complications are shown in Table 3. Three of four patients with poor

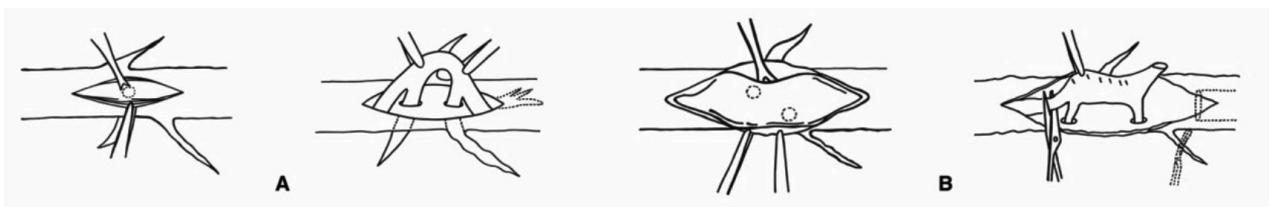


Figure 1 A) Closed endarterectomy; B) open endarterectomy

Table 1 Preoperative characteristics of patients

Characteristic	N = 17 (%)
Age	58.9 ± 7.7
Men	15 (88)
BMI	26.2 ± 3.0
Morbid obesity	2 (12)
Active smoking	1 (6)
HT	17 (100)
DLP	17 (100)
DM	10 (59)
Poor LVEF	4 (24)
Renal insufficiency	13 (77)
CKD	9 (52)
ESRD	4 (23)

Table 2 Operative findings and procedures

	N = 17 (%)
Non-elective	3 (18)
Anastomoses per patient	
OPCAB x 1	1 (6)
OPCAB x 2	2 (12)
OPCAB x 3	13 (77)
OPCAB x 4	1 (6)
Open CE	1 (6)
Close CE	16 (94)
Target CE	
LAD	13 (77)
PDA	1 (6)
LAD + OM	1 (6)
LAD + PDA	2 (12)
> 1 CE	3 (18)
Conversion rate	0
Prophylactic IABP	13 (77)
Therapeutic IABP	1 (6)

pre-operative LVEF improved postoperatively, as seen on echocardiography before discharge from the hospital. The mean ICU stay was 4 days and mean hospital stay was 12 days.

DISCUSSION

The principal goal in coronary artery bypass grafting (CABG) is to achieve complete revascularization of diseased coronary arteries.¹⁵ Coronary endarterectomy (CE) establishes sufficient blood supply by directly removing plaques obstructing flow to the targeted vessels.¹⁶ CE can achieve revascularization when typical

Table 3 Post-operative outcomes of patients

Outcomes	N = 17 (%)
In-hospital mortality	0
Late mortality	1 (6)
Re-intervention	0
LCOS	1 (6)
Peri-operative MI	1 (6)
AF	3 (18)
Stroke	0 (0)
Re-sternotomy for bleeding	1 (6)
HAP	2 (12)
Superficial sternal infection	1 (2)
New need for hemodialysis	0
Length of ICU stay (days)	4 (2 to 20)
Length of hospital stay (days)	12 (8 to 40)
Poor LVEF	1 (6)

anastomoses are not possible due to severe calcification or soft plaques. The application of adjunct CE remains controversial due to its high morbidity and mortality.

Avoidance of cardiopulmonary bypass may be particularly beneficial in high-risk patients with poor LVEF because OPCAB may reduce global myocardial ischemia, lower transfusion requirements and improve short-term morbidity.¹⁷ Furthermore, other comparative studies demonstrate at least equivalent 30-day mortality between OPCAB-CE and ONCAB-CE. MI rates were comparable between OPCAB and ONCAB techniques.¹⁷⁻¹⁹

A systematic review conducted by Soylu et al., in 2014 have shown a mortality rate of 0 to 3.1%, 0 to 15% peri-operative MI, 0 to 3% stroke, and 5 to 20% POAF.¹⁷ In the present study, there was no in-hospital mortality but 6% late mortality. There was no re-intervention, though a 6% LCOS, 6% perioperative MI, 18% POAF, no stroke, no new need of hemodialysis, 18% HAP, 6% massive bleeding and 6% superficial sternal wound infection.

The optimal technique for performing endarterectomy remains controversial. The advantages of closed technique over opened technique included a small arteriotomy, shorter operative time and easier graft anastomoses. However, there are also some disadvantages including branch injuries, thrombosis, dissection and insufficient endarterectomy.²⁰⁻²¹

Soylu et al., in 2014 have shown that the open technique had lower 30-day mortality but it was not of

clinical significance. There was insufficient evidence to show that the closed technique affected the incidence of post-operative MI. No correlation between any particular coronary vessel undergoing CE and incidence of MI was found. However, patients who have had more than single-vessel endarterectomy also had a higher possibility of infarction.¹⁷

Postoperative MI resulting from embolization of atheromatous debris or de novo thrombogenesis remains a fundamental concern following CE.^{11,22-23} So far there is no clear guidelines recommending pharmacotherapy in patients who had CABG with CE. In the literature, various anti-platelet treatment and anticoagulation regimens have been recommended. At some institutions LMWH was given until patients were fully mobilized. Some patients received dual anti-platelet therapy from the first day till the end of the third month after surgery.²⁴

Other studies advised using intravenous heparin administered postoperatively for several days. Low-dose aspirin (100 mg/day) and warfarin (maintained with a target international normalized ratio of 2.0) were prescribed. Intravenous heparin may be continued until warfarin was effective. After 3 months, administration of warfarin may be stopped. Aspirin was continued indefinitely in all patients.¹³

Adding coronary artery endarterectomy to the standard coronary artery bypass grafting procedure could be indicated in some cases. CE cannot replace CABG and it should be regarded as a therapeutic option that is proper in specific patients despite its risk. Selection of proper cases and great caution when performing CE are essential skills in achieving an optimal outcome. The benefits of obtaining complete revascularization over risks should be considered in those patients. Further research is necessary.

The limitations of the present clinical study included the small number of patients; the lack of post-operative angiography; the retrospective observational design; and the lack of long-term clinical follow-up.

CONCLUSION

Advanced diffuse CAD remains a challenging condition for surgical coronary revascularization. OPCAB with coronary endarterectomy is an alternative procedure with low mortality and acceptable complication rate, under the hands of highly experienced surgeons. However, long-term clinical outcomes and angiographic data are still lacking.

REFERENCES

1. Bell MR, Gersh BJ, Schaff HV, et al. Effect of completeness of revascularization on long-term outcome of patients with three-vessel disease undergoing coronary artery bypass surgery. A report from the Coronary Artery Surgery Study (CASS) Registry. *Circulation* 1992;86:446-57.
2. Lawrie GM, Morris GC Jr, Silvers A, et al. The influence of residual disease after coronary bypass on the 5-year survival rate of 1274 men with coronary artery disease. *Circulation* 1982;66:717-23.
3. Jones EL, Craver JM, Guyton RA, et al. Importance of complete revascularization in performance of the coronary bypass operation. *Am J Cardiol* 1983;51:7-12.
4. Bailey CP, May A, Lemmon WM. Survival after coronary endarterectomy in man. *J Am Med Assoc* 1957;164:641-6.
5. Livesay JJ, Cooley DA, Hallman GL, et al. Early and late results of coronary endarterectomy. Analysis of 3,369 patients. *J Thorac Cardiovasc Surg* 1986;92:649-60.
6. Brenowitz JB, Kayser KL, Johnson WD. Results of coronary artery endarterectomy and reconstruction. *J Thorac Cardiovasc Surg* 1988;95:1-10.
7. Minale C, Nikol S, Zander M, et al. Controversial aspects of coronary endarterectomy. *Ann Thorac Surg* 1989;48:235-41.
8. Sahan E, Sahan S, Karamanlioglu M, et al. The impact of the extent and severity of coronary artery disease on fractional flow reserve measurements. *Eur Rev Med Pharmacol Sci* 2016;20:343-9.
9. Anderson HV, Stokes MJ, Leon M, et al. Coronary artery flow velocity is related to lumen area and regional left ventricular mass. *Circulation* 2000;102:48-54.
10. Careaga Reyna G, Salazar Garrido D, Tellez Luna S, Arguero Sanchez R. [Coronary endarterectomy and bypass grafting without cardiopulmonary bypass]. *Rev Espan Cardiol* 2003;56:515-8.
11. Darwazah AK, Abu Sham'a RA, Yasin IH. Coronary endarterectomy on beating heart: is it worth doing? *J Card Surg* 2007;22:69-72.
12. Eryilmaz S, Inan MB, Eren NT, et al. Coronary endarterectomy with off-pump coronary artery bypass surgery. *Ann Thorac Surg* 2003;75:865-9.
13. Takahashi M, Gohil S, Tong B, et al. Early and mid-term results of off-pump endarterectomy of the left anterior descending artery. *Interact Cardiovasc Thorac Surg* 2013;16:301-5.
14. Vohra HA, Kanwar R, Khan T, Dimitri WR. Early and late outcome after off-pump coronary artery bypass graft surgery with coronary endarterectomy: a single-center 10-year experience. *Ann Thorac Surg* 2006;81:1691-6.
15. Kolh P, Windecker S, Alfonso F, et al. 2014 ESC/ EACTS Guidelines on myocardial revascularization: the Task Force on Myocardial Revascularization of the European Society of Cardiology (ESC) and the European Association for Cardio-Thoracic Surgery (EACTS). Developed with the special contribution of the European Association of Percutaneous Cardiovascular Interventions (EAPCI). *J Eur Assoc Cardiothoracic Surg* 2014;46:517-92.
16. Parsonnet V, Gilbert L, Gielchinsky I, Bhakta EK. Endarterectomy of the left anterior descending and mainstem coronary

arteries: a technique for reconstruction of inoperable arteries. *Surgery* 1976;80:662-73.

17. Soylu E, Harling L, Ashrafi H, Athanasiou T. Should we consider off-pump coronary artery bypass grafting in patients undergoing coronary endarterectomy? *Interact Cardiovasc Thorac Surg* 2014;19:295-301.
18. Naseri E, Sevinc M, Erk MK. Comparison of off-pump and conventional coronary endarterectomy. *Heart Surg Forum* 2003;6:216-9.
19. Hussain I, Ghaffar A, Shahbaz A, et al. In hospital outcome of patients undergoing coronary endarterectomy: comparison between off-pump vs on pump CABG. *J Ayub Med Coll* 2008;20:31-7.
20. Gol MK, Yilmazkaya B, Goksel S, et al. Results of right coronary artery endarterectomy with or without patch-plasty. *J Card Surg* 1999;14:75-81.
21. Nishi H, Miyamoto S, Takanashi S, et al. Optimal method of coronary endarterectomy for diffusely diseased coronary arteries. *Ann Thorac Surg* 2005;79:846-52.
22. Kunt AS, Darcin OT, Demirbag R, Andac MH. Coronary endarterectomy with beating heart in patients with diffuse atheromatous coronary artery disease and poor ventricular function: early and midterm results. *Heart Surg Forum* 2005;8:E124-8.
23. Nurozler F, Kutlu T, Kucuk G, Okten C. Off-pump coronary endarterectomy in high-risk patients. *Asian Cardiovasc Thorac Ann* 2006;14: 227-30.
24. W. Domaradzki , K. Sanetra, J. Krauze, et al. Coronary endarterectomy in left anterior descending artery combined with coronary artery bypass grafting—midterm mortality and morbidity. *Kardiochirurgia i Torakochirurgia Polska* 2015;12:304-8.