

# Techniques and Results of Off-Pump Coronary Artery Bypass Grafting Using Homemade Intracoronary Shunt

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**Background:** The outcome of the off-pump coronary artery bypass grafting (CABG) is highly dependent on surgical techniques. To overcome problems of intraoperative hemodynamic instability and avoid potential injury to coronary artery arising from occlusive technique, the authors have modified the strategy of performing distal anastomosis by using the authors' homemade intracoronary artery shunt.

**Objective:** To document the results of off-pump CABG using the authors' homemade intracoronary shunt. The characteristics of shunt and techniques are demonstrated.

**Material and Method:** The shunt is constructed from silicone tubing (Allied Biomedical Company, Paso Robles, CA). It has been successfully used for distal anastomoses in off-pump coronary artery bypass surgery. All 170 consecutive patients who had off-pump CABG from October 2002 to May 2005 were evaluated. Data were collected retrospectively. Average grafts per patient were 3.5. Arterial grafts were used in most cases (90%). Conversion rate was 2.8%. Patients were followed up at 3 weeks, 6 weeks, and bimonthly thereafter.

**Results:** In a 23-month follow-up, the operative mortality rate was 0.5% (one patient). Complications included stroke in 3 patients (1.8%) and post-operative AF in 12 patients (7.12%). Of 170 patients, 12 patients (7.05%) required intraoperative or postoperative intraaortic balloon pump support. The early results were good and satisfactory.

**Conclusion:** Off-pump CABG can be successfully performed using the authors' homemade intracoronary artery shunt with better hemodynamic control. The techniques are safe, simple, reliable, and effective.

**Keywords:** Ramathibodi intracoronary shunt, Off-pump CABG

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With the advance in instrumentation, tissue stabilizer, and heart positioner, more than 30% of coronary artery bypass surgeries are performed in most centers without the use of a heart lung machine<sup>(1,2)</sup>. Nevertheless, the problems of hemodynamic instability during the procedure still remain<sup>(3,4)</sup>. Hence, intracoronary shunt has been introduced in 1999<sup>(5)</sup>. There are a few commercially available intracoronary shunts in Thailand, but they are very costly. In addition, they have some limited properties that cause dis-

advantages in clinical use. The authors, therefore, have successfully modified and developed their own homemade device from available medical supplies in conventional operating room to be used as an intracoronary shunt. The developmental process, shunt characteristics, surgical procedure and clinical results are discussed.

## Material and Method

From October 2002 to May 2005, the authors performed 175 coronary artery bypass graft surgeries on a beating heart. Off-pump operation was performed on 170 patients while surgeries on 5 patients were carried out with pump assistance. The study protocol

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was approved by the Ethical Committee of Ramathibodi Hospital, Mahidol University, Bangkok, Thailand. Initially, the distal anastomoses were performed using several methods such as proximal occlusion of coronary vessels and commercially available intracoronary shunt. During this period there were 170 isolated off-pump CABG operations where intracoronary shunts were used for distal anastomoses. The percentage use of off-pump CABG cases has risen from 34.86% in 2003 to 93.67% in 2004.

### **Ramathibodi Intracoronary Shunt**

Ramathibodi Intracoronary Shunt or Rama ICS (Fig. 1) is a device used for insertion into the coronary artery via arteriotomy while performing distal anastomosis in off-pump CABG. Rama ICS is made of inexpensive materials easily found in the operating room. The assembling process is simple and easy. A set of the Rama ICS consists of silicone tube (Allied Biomedical Corporation, Paso Robles, CA), midpoint attachment silk (CV 301, Ref. 1252-31, USS & DG, CA), and titanium haemostatic clip (Ref. LT 200, Ethicon Endo-surgery Inc., NJ). Various sizes were produced including four transverse diameters that come in three different lengths (Table 1). The sizes can be selected to match the diameter of each coronary artery. Rama shunt has seven characteristics that are different and potentially better than the commercially available shunt in Thailand (Table 2). The homemade shunt is success-

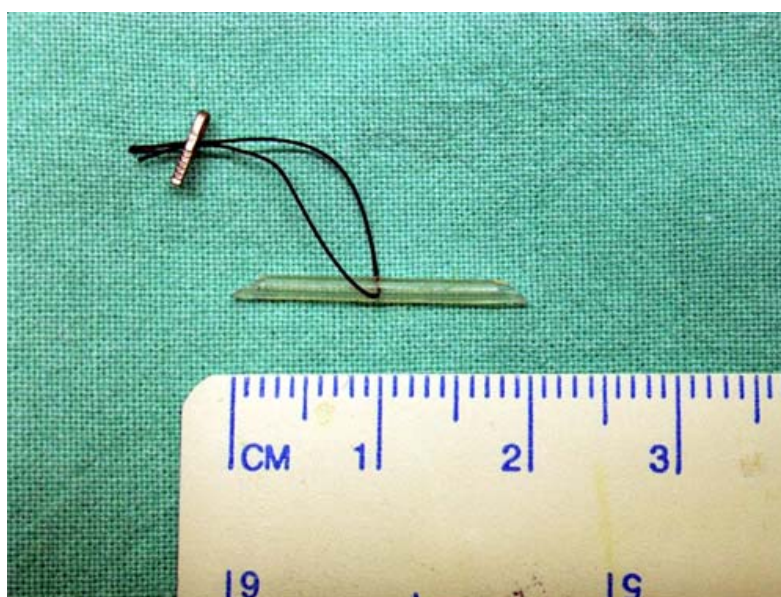
**Table 1.** Variable sizes of Intracoronary shunt

Transverse diameter Internal x External		Length
Inch	Millimeter	Millimeter
0.02 x 0.037	0.58 x 0.94	10
0.025 x 0.047	0.635 x 1.20	20
0.030 x 0.065	0.762 x 1.651	30
0.040 x 0.08	1.0 x 2.0	

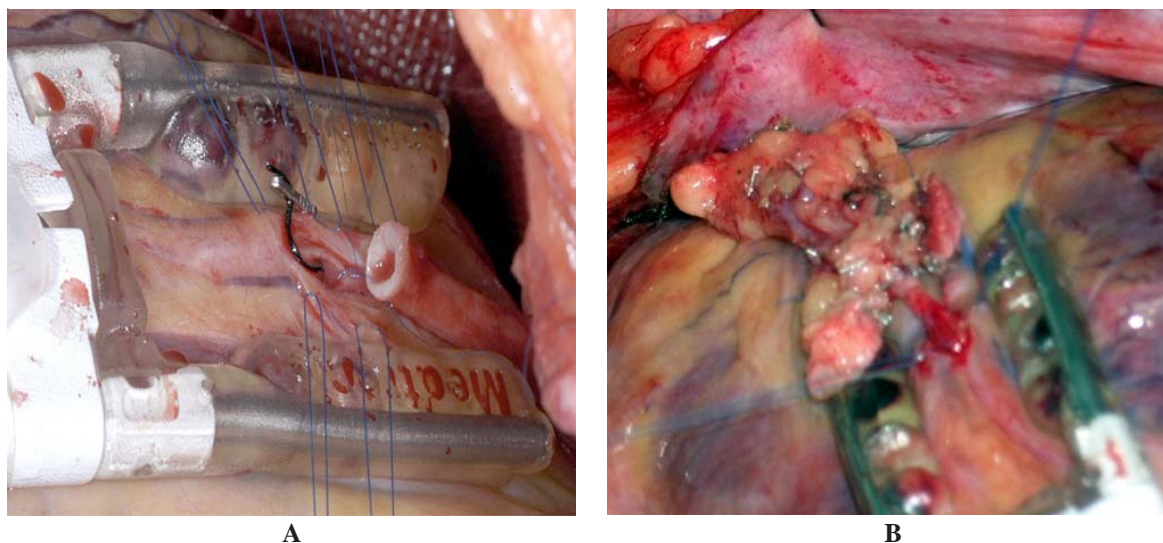
**Table 2.** Characteristics of the Ramathibodi Intracoronary Shunt

1. Homemade
2. Flexible, bendable, returnable shape
3. Soft, no bulb-tip
4. Translucent
5. Available in 12 sizes
6. Adjustable length and tip
7. Cost effective

fully applied for clinical use in off-pump CABG. It improves the efficiency of surgery and is cost effective. The shunt has been used at the Faculty of Medicine, Ramathibodi Hospital for over two years. It helps the patient to save the operating cost and complies with the hospital policy to modify the existing medical supplies for optimum usage and benefit.



**Fig. 1** Ramathibodi Intracoronary Shunt 20 mm, 0.762 x 1.651mm<sup>2</sup>



**Fig. 2** A) Anastomosis of saphenous vein graft to posterior descending coronary artery with intracoronary shunt inside  
 B) Completed anastomosis of left internal thoracic artery to left anterior descending coronary artery

Rama Intracoronary Shunt provides continuous blood flow through the coronary artery while performing distal coronary anastomoses. It prevents regional myocardial ischemia and further myocardial stunning. Furthermore, direct injury to the coronary artery created by occlusive technique is also avoided. The shunt provides good exposure and relatively bloodless operative field, thereby maintaining hemodynamics during the surgical procedure.

#### **Surgical Technique**

In the present study, median sternotomy was performed. The off-pump procedure was carried out using Octopus 3 tissue stabilizer and starfish heart positioner (Medtronic Inc., Minneapolis, MN). Coronary arteriotomy was made longitudinally with a no. 15 blade knife. A shunt of appropriate size was selected and inserted proximally with one end and then distally with the other end. The distal anastomosis was performed as usual with 7-0 polypropylene suture (Fig. 2). When the suturing procedure was nearly completed, the shunt was removed by pulling the attached string. Eventually, the suture was tied and hemostasis was secured.

#### **Data analysis**

All data were collected retrospectively from a computer database. Intraoperative data were entered at the time of operations. Patients were followed up at 3 weeks, 6 weeks, and bimonthly thereafter. Values were

expressed as mean  $\pm$  SD. Percentages were also given whenever appropriate.

#### **Results**

The authors have performed off-pump CABG on 170 patients. Patient demographics are shown in Table 3. The shunt has been successfully used in almost all distal anastomoses. The operative mortality was 0.6% (one patient). The cause of death was thought to be due to systemic inflammatory response syndrome (SIRS). Neither postoperative ischemia nor perioperative infarction was observed among the presented patients. There was no postoperative re-sternotomy

**Table 3.** Patient demographics (n = 170)

N	N (%)
Age (year), range, and mean $\pm$ SD	44-81, 68.5 $\pm$ 11.4
Male, Female	105, 65
Diabetes Mellitus	69 (40.58)
COPD	67 (39.4)
Left main stenosis	58 (34.11)
Severe LV dysfunction (LVEF < 30%)	66 (38.82)
Renal dysfunction (Serum Cr > 2mg/dl)	23 (13.52)
ESRD on hemodialysis	8 (4.7)
Urgent operation	19 (11.17)

COPD = Chronic obstructive pulmonary disease

LVEF = Left ventricular ejection fraction

ESRD = End stage renal disease

for bleeding. Conversion rate to conventional CABG was 1.6% (3 patients) and that to on-pump beating heart technique was 2.8% (5 patients). Twelve patients (7.1%) required intraaortic balloon pump and post-operative atrial fibrillation was also found in this group of patients. Other complications were observed, i.e., stroke in 3 patients (1.8%) and wound infection in 4 patients (2.4%). Two patients with very poor left ventricular function (LVEF < 20%) and refractory ventricular tachycardia underwent automatic implantable cardioverter defibrillator implantation before hospital discharge.

All patients were followed up until May 2005 when the follow up was completed. Mean follow up was  $15.5 \pm 7.4$  months. One patient presented with angina after 18 months, and repetitive coronary angiograms revealed a perfectly patent graft. Fourteen months after the operation, one patient died of end stage renal failure due to renal disease progression.

### Discussion

Conventional CABG can be performed worldwide at low risk with very good results<sup>(6,7)</sup>. It is recognized as a gold standard treatment for surgery of coronary artery disease. However, current techniques need cardiopulmonary bypass, aortic clamping, cannulation, and cardioplegic arrested heart. Thus, off-pump CABG has been adopted worldwide over the past several years. Advances in surgical technique, cardiac anesthesia and instrumentation have facilitated the procedure and maintained improving results<sup>(8,9)</sup>.

The advantages of off-pump technique are to avoid the untoward effects of cardiopulmonary bypass (CPB), manipulation of aorta during cannulation and cross-clamping. Although advances in CPB technology have resulted in much safer cardiac surgical procedures, the consequences of CPB can be severe<sup>(10,11)</sup>. This is more prominent, especially in high-risk patients undergoing CABG<sup>(12)</sup>.

In off-pump CABG, the performance of safe and reliable distal coronary anastomoses depends on an adequate surgical exposure, a stabilization of the target coronary artery and a relatively bloodless field. Proximal and distal occlusion of the coronary artery may result in direct arterial injury and poor long term patency<sup>(13,14)</sup>. Temporary occlusion of major coronary arteries may result in regional ischemia and myocardial stunning<sup>(15)</sup>. The use of intracoronary shunts provides continuous coronary blood flow while performing a nastomoses, prevents regional myocardial damage, and ensures hemodynamic stability during off-pump

CABG<sup>(16,17)</sup>. In addition, a shunt with a bulb-tip may cause endothelial injury in the region where the bulb is situated<sup>(18)</sup>. Even though the authors' homemade shunt has no bulb tip, is very soft, and has potentially less injury, the authors would recommend employing the shunt selectively and cautiously.

With the authors' Ramathibodi intracoronary shunt, the distal anastomosis can be performed regularly under bloodless operative field and clear visualization. The present results of off-pump CABG in 170 patients during a period of 2.5 years have been rewarding and able to be compared with the others described elsewhere<sup>(19-21)</sup>.

### Conclusion

In the present study, the clinical application of the authors' homemade intracoronary shunt was clearly demonstrated. The use of the intracoronary artery shunt in off-pump CABG can help maintain better hemodynamics during the procedure, avoid injury with occlusive technique and provide good exposure. The technique is simple, reliable, and effective. So far, the authors have successfully performed off-pump CABG using the homemade intracoronary shunt with excellent results.

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## ผลการศึกษาและวิธีการผ่าตัดต่อเส้นเลือดหัวใจแบบไม่ใช้เครื่องปอดและหัวใจเทียม โดยใช้ท่อนำเลือดหล่อเลี้ยงหัวใจ รามาธิบดี

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**ที่มา:** ผลการผ่าตัดต่อเส้นเลือดหัวใจแบบไม่ใช้เครื่องปอดและหัวใจเทียมขึ้นอยู่กับเทคนิคการผ่าตัดเป็นอย่างมาก เพื่อลดปัญหาของภาวะระบบไหลเวียนเลือดไม่คงที่ระหว่างผ่าตัด และการบาดเจ็บต่อเส้นเลือดหัวใจ คณะผู้วิจัยได้ดัดแปลงกลยุทธ์และเทคนิคเพื่อใช้ในการผ่าตัดต่อเส้นเลือดหัวใจบริเวณรอยต่อส่วนปลาย ขณะทำการผ่าตัดเส้นเลือดหัวใจโดยใช้ท่อนำเลือดหล่อเลี้ยงหัวใจที่ประดิษฐ์ขึ้นใช้เองใน โรงพยาบาลรามาธิบดี

**วัตถุประสงค์:** เพื่อศึกษาผลของการผ่าตัดแบบไม่ใช้เครื่องปอดและหัวใจเทียมโดยใช้ท่อนำเลือดหล่อเลี้ยงหัวใจ รามาธิบดี และเพื่อแสดงรายละเอียดคุณลักษณะเฉพาะตัวของท่อนำเลือดหล่อเลี้ยงหัวใจรามาธิบดี ตลอดจนจนเทคนิคการผ่าตัด

**วัสดุและวิธีการ:** ท่อนำเลือดหล่อเลี้ยงหัวใจรามาธิบดี ดัดแปลงและประดิษฐ์มาจากวัสดุอุปกรณ์ที่หาได้ในห้องผ่าตัด ทำได้ง่าย ราคาถูก ได้ถูกนำมาประยุกต์ใช้ในทางคลินิกในผู้ป่วยโรคเส้นเลือดหัวใจตีบที่ต้องได้รับการผ่าตัดต่อเส้นเลือดหัวใจจำนวน 170 ราย ระหว่างเดือนตุลาคม พ.ศ. 2546 – พฤษภาคม พ.ศ. 2548 ข้อมูลของผู้ป่วยได้รับการบันทึก ประเมิน และติดตามผลแบบย้อนหลัง

**ผลการศึกษา:** จากการศึกษาในกลุ่มผู้ป่วย 170 ราย พบว่ามีอัตราเสียชีวิตจากการผ่าตัด 0.5% ผลแทรกซ้อนอื่น ๆ จากการผ่าตัดได้แก่ ภาวะสมองขาดเลือดแบบชั่วคราว 1.8%, ภาวะ Atrial fibrillation หลังผ่าตัด 7.12%, พบว่าผู้ป่วย 7.05% ใช้เครื่องพุงตัวการทำงานของหัวใจผู้ป่วยที่ได้รับการติดตามผลในระยะแรกแสดงผลดีจากการผ่าตัด และมีภาวะแทรกซ้อนน้อย

**สรุป:** จากการศึกษาและติดตามผลการผ่าตัดต่อเส้นเลือดหัวใจแบบไม่ใช้เครื่องปอดและหัวใจเทียมพบว่าท่อนำเลือดหล่อเลี้ยงหัวใจรามาธิบดี สามารถนำมาประยุกต์ใช้ในทางคลินิกได้อย่างมีประสิทธิภาพและเป็นผลสำเร็จอย่างดี

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