# Advancements in Coronary Artery Bypass Grafting: A Retrospective Analysis of 201 Cases at Chittagong Medical College Hospital

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## Abstract

**Background:** The establishment of Cardiac Surgery at Chittagong Medical College Hospital (CMCH) in 2012 marked a significant milestone for Coronary Artery Bypass Grafting (CABG) in the region. CABG requires a skilled multidisciplinary team, including surgeons, anesthetists, perfusionists, operating theater and ICU staffs. This study evaluates the outcomes of CABG procedures at CMCH, addressing the challenges of starting such services in an underserved area.

**Methods:** A retrospective analysis was performed on 201 patients who underwent CABG at CMCH between April 2013 and December 2023. Data on patient demographics, surgical techniques, perioperative complications and postoperative outcomes were analyzed to assess mortality and morbidity.

**Results:** The outcomes showed minimal operative mortality and low postoperative morbidity. Mortality was confined to early postoperative complications, with no intraoperative deaths. Perioperative issues like myocardial infarction, arrhythmias and pulmonary complications were less and managed effectively, with satisfactory ICU support and hospital stay durations.

**Conclusion:** CABG surgery at CMCH is safe and effective, with results comparable to national and international standards. The success highlights the importance of skilled teams and comprehensive care, demonstrating CMCH's ability to offer safe cardiac surgery despite early challenges.

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## Introduction

CABG is a major surgery performed on patients with Coronary Artery Disease (CAD) a condition that blocks blood flow to the heart and is the leading cause of death worldwide, especially in the U.S., Europe, and Australia. Additionally, CAD is the most common cause of heart failure.[1] The surgery is usually done when other treatments, like medication or angioplasty, don't work to relieve symptoms like chest pain (Angina). CABG not only helps improve the patient's quality of life but also reduces the chances of serious heart problems, like heart attacks.[2] The CABG operation has become the most completely studied operation in the history of surgery. The surgical management of patients with severe coronary artery disease improves long-term survival.There is general agreement that CABG improves prognosis in the early post-surgical years in those patients with symptomatic left main coronary artery stenosis or stenosis of the three main coronary vessels.[2]

The development of the Coronary Artery Bypass Grafting (CABG) operation is undoubtedly one of the greatest surgical achievements of the 20th century. Millions of patients have undergone CABG since it was introduced into clinical practice in the 1960s. In 1962, a cardiac surgeon by the name of Sabiston conducted the first unsuccessful saphenous vein graft from the ascending aorta to the distal right coronary artery and the patient died 3 days later. The technique was pioneered by Argentinian René Favaloro and others at the Cleveland Clinic in the late 1960s. The next major development was in 1970, when the internal mammary artery was used as a bypass conduit to the coronary arteries.[3] Vasilii I. Kolesov, a cardiac surgeon from Leningrad, performed the first sutured internal mammary artery-coronary artery anastomosis on Feb. 25, 1964.[4] He used the

internal mammary artery pedicle (Kolesov's pedicle) and described beadlike nodules and a dimpling of the epicardium over the atherosclerotic coronary artery (Kolesov's groove sign). Since 1964, CABG has been performed regularly and the number of procedures has increased dramatically. Yet it should be remembered that from 25 February 1964 to 9 May 1967 the department of surgery headed by Vasilii I. Kolesov was the only place in the world where CABG operations were performeed.[3,4,5] Use of the Radial Artery (RA) as a bypass conduit was introduced by Carpentier in 1971. By the mid 1970s, many centers in the United States, Australasia and Europe were performing CABG with low peri-procedural mortality and a high rate of pain relief.[6] Establishing a cardiac surgery unit is costly and requires collaboration among specialists like surgeons, anesthetists, cardiologists, perfusionists, and ICU staff, with support from physiotherapy, the blood bank and other departments.[7] In CMCH, the first CABG surgery was performed on November 8, 2012, by a Turkish cardiac surgical team, and on March 31, 2013, we, the hospital's own cardiac surgical team conducted our inaugural CABG procedure.[8] The responsibility is immense, as CMCH became one of the few hospitals in the region offering such a complex procedure without backup support.

CMCH didn't stop at regular CABG procedures. They also adopted Off-Pump Coronary Artery Bypass (OPCABG) which doesn't use a heart-lung machine and Minimally Invasive Direct Coronary Artery Bypass (MIDCABG) which involves a smaller incision. These advancements have helped make the surgery recovery times faster and less expensive for patients.[9]

The success of our unit depends on achieving favorable results, at least comparable to national and international standards, initiation of research projects and promotion of medical education and training. The initial phase of establishing such a discipline with competent surgical procedures is both challenging and demanding.[7] We describe here our experience with one of the active cardiac surgical service CABG. We reviewed the outcome in the first 201 cases of Coronary Artery Bypass (CABG) surgery that underwent at Chittagogong Medical college Hospital by its' own team.

**Materials and methods**

This retrospective cohort study reviewed data from 201 patients with Coronary Artery Disease (CAD) who underwent Coronary Artery Bypass Grafting (CABG) surgery at Chittagong Medical College Hospital (CMCH) between March 2013 and December 2023. CMCH, a tertiary referral center, accepts patients with CAD referred by cardiologists, some of whom were diagnosed and catheterized in-house, while others were referred from external facilities. All patients who met the surgical criteria were included in the study.

Of the 201 cases, 176 were conventional CABGs, while the remaining involved Off-Pump CABG (OPCABG) and Minimally Invasive Direct CABG (MIDCABG). Preoperative assessment and risk stratification were conducted using the EuroSCORE system.[10]

The criteria for inclusion were:

- Presence of Ischemic Heart Disease (IHD) with ≥70% arterial lumen narrowing.
- Suitable anatomy of epicardial vessels (>1mm, non-calcified).
- Absence of severe cardiomegaly.
- Left ventricular ejection fraction >30%.
- No cardiac arrhythmias.
- Cases involving myocardial revascularization with other associated procedures (e.g. valve replacement).

No emergency CABG procedures were included in the study. All patients were carefully studied and documented.

Most Coronary Artery Bypass Grafting (CABG) surgeries were performed via a median sternotomy incision with the patient in a supine position under general anesthesia. The Left Internal Mammary Artery (LIMA) was harvested as a skeletonized graft using a LIMA retractor, ensuring sufficient blood flow. Simultaneously, the great saphenous vein was harvested from the leg. Both conduits were prepared with a solution containing medications like GTN, Verapamil, heparin and ringer's lactate or papaverine mixed with blood and normal saline.

In conventional CABG, after LIMA harvesting, Cardiopulmonary Bypass (CPB) was established using aortic and venous cannulation, with full

heparinization. CPB was performed with a non-pulsatile system, maintaining a mean arterial pressure around 50 mm Hg and a hematocrit above 20%. Hypothermia between 28°C to 32°C was used. Cold blood cardioplegia, either intermittent St. Thomas or Del Nido solution, was administered after aortic cross-clamping to induce cardiac arrest and protect the myocardium. Distal coronary anastomoses followed the RCA/PDA, OM, Diagonal and LAD sequence.

For Off-Pump CABG (OPCABG) coronary anastomoses were performed on the beating heart using stabilizers like Octopus and Starfish, with intracoronary shunts to maintain blood flow. LIMA was grafted primarily to the LAD, unless flow was inadequate. Proximal anastomoses were completed on the ascending aorta with a side-biting clamp.

In Minimally Invasive Direct CABG (MIDCABG) a small anterior incision in the left 5th intercostal space allowed LIMA harvesting and grafting. Stabilizers and intracoronary shunts facilitated the procedure.

Postoperatively, patients were electively ventilated and typically weaned within hours. ICU and ward monitoring followed, with cardiac rehabilitation and physiotherapy. Dual antiplatelet therapy (Aspirin-Clopidogrel) and magnesium sulfate were routinely administered, and patients were generally discharged by the 7th postoperative day. Before commencement of the study necessary permission was obtained from the proper authority.

**Results**

The data for the first 201 cases are summarized in Tables I-V. Table I outlines the main preoperative characteristics. The population included 21 females (10.45%) and the rest were male, with a mean age of 56.3±26.4 years (Range 29-76). Most patients (94, 46.77%) were in the 50-59 age group. Severe angina (CCS class III or higher) affected 127, 63.18% of patients, while 24.87% had exercise-induced dyspnea. High incidences of hypercholesterolemia (58.7%), smoking (59.7%), and family history of coronary heart disease (38.3%) were noted. Hypertension and diabetes affected 39.3% and 38.3%, respectively. Pre-op MI was reported in 15.92% of patients, with smaller percentages having COPD, stroke, or CKD.

Angiographic data showed 19.9% had ≥ 50% left main coronary stenosis and 79% had triple-vessel disease (≥ 70% lesion in LAD, LCX and RCA system). A smaller number (>15%) had double-vessel disease and Single vessel disease patients who were failed for PTCA or previously PTCA done but In Stent Restenosis (ISR) developed was undergone CABG here 8 (4%) in number. The mean preoperative ejection fraction was 49.2±17.6%. Full details are in Table I.

Regarding the type of grafts, the majority of patients received a combination of left internal mammary artery and saphenous veins. Conduit was grafted per person 2.78± 1.25 (range 1 to 4 grafts/patient). Of these 201 cases, the left Internal Mammary Artery (IMA) was used in 194 (96.51%) cases, and no bilateral IMAs were used. Of these 201 patients, no reoperation (redo) was performed.

Table II showed 201 patients received a total 559 distal grafts anastomosis in which 194 (96.51%) were Left Internal Mammary Artery (LIMA) conduit and 365 were Great Saphenous Vein (GSV) conduit. Among 193 LAD arteries, 189 (94.02%) were bypassed with LIMA (No patients had bilateral mammary conduits) and 4(2%) were bypassed with GSV graft. Venous grafts used in LAD due to inadequate flow in LIMA. 1 LAD artery was non graftable so its' Diagonal branch was grafted with LIMA conduit. 7 patients had single IMA conduits which were performed with OPCABG and MIDCABG. Coronary artries grafted were LAD 193 (96%), RCA/PDA 166 (82.59%), Diagonal (D) 21 (10.45%), Marginal branches (OM) 163 (81.09%), Ramus Intermedius (RI) 12(5.97%), others (PLB /RV Branch) 2(0.99%). During proximal anastomosis we found presence of plaque and atherosclerosis in 8(4.08%) patient's aortic wall.

Median sternotomy was used in 99% of cases, with MIDCAB employed in 1%. Two cases required conversion from off-pump to on-pump surgery due to heart failure and hemodynamic or electrical instability; both patients recovered fully. No reoperations were performed.

The results of CABG surgery in 201 cases are summarized in Table-III. There was no intraoperative mortality, but 14 patients (6.96%) experienced early postoperative mortality due to intractable ventricular tachycardia, ventricular

fibrillation, and low output syndrome on the 1st postoperative day. Six patients (2.98%) had perioperative infarcts based on new Q waves or a peak aspartate aminotransferase ≥100 IU/mL.

Postoperative morbidity included cerebrovascular accidents in 1 patient (0.5%) with transient hemiplegia and aphasia on the 2nd postoperative day, which fully regressed by the 4th day. Eight patients required re-exploration: 7 for postoperative hemorrhage and 1 for graft thrombosis. One patient developed cardiac tamponade, necessitating re-sternotomy. Transfusion of over 5 units of donor blood was required in 6 cases.

Arrhythmias developed in 26 patients (12.93%): 10 (4.97%) with Atrial Fibrillation (AF) 9 (4.48%) with SVT and 4 (2%) with ventricular tachycardia, one of whom died despite DC shock. Three patients had premature ventricular ectopics, treated with lignocaine and amiodarone. All AF and SVT were managed with digoxin, verapamil, amiodarone and magnesium sulfate and restored sinus rhythm in all cases. No complete heart block requiring a permanent pacemaker was observed.

Pulmonary complications occurred in 12 patients, including respiratory failure, pulmonary edema, significant atelectasis and pleural effusion, with 4 (2%) requiring intercostal tube insertion. The mean intubation period was 10.2 ±2.4 hours, 7 patients needed prolonged ventilation (>24 hours). Superficial sternal wound infections occurred in 8 patients (4%) and leg wound infections in another 8 (4%), all treated conservatively. One patient (0.5%) developed deep chest wound infection with mediastinitis. Two patients had postoperative psychosis requiring medication. Four (2%) developed acute renal failure; 2 needed hemodialysis, with one recovering and one dying on the 5th POD. One patient required an Intra-Aortic Balloon Pump (IABP) for low ejection fraction.

In this study, the postoperative ICU stays averaged 60±8 hours, and the average hospital stay was 7±4 days. All patients were followed up as outpatients, with very satisfactory results. Three months after CABG surgery, follow-up echocardiograms (2D and M mode) showed a significant improvement in Left Ventricular Ejection Fraction (LVEF) to 55.2±23.6% (p <.01). However, LVEF decreased in 4 patients compared to the preoperative period.

**Table I** Patients characteristics of IHD undergone CABG

| Variables | Number of patients n= 201 (%) |
|---|---|
| Age in years (Mean ± SD) | 56.3±26.4 |
| 21-30 y | 1 (0.5% ) |
| 31-40 y | 14 (6.96% ) |
| 41-50 y | 62 (30.84% ) |
| 51-60 y | 94 (46.77% ) |
| 61-70 y | 29 (14.43% ) |
| 71-80 y | 1 (0.5% ) |
| Female | 21 (10.45%) |
| Pre-op MI | 32 (15.92%) |
| Unstable angina (UA) | 75 (37.31%) |
| Smokers | 120 (59.7%) |
| Hypertension | 79 (39.30%) |
| Diabetes | 77(38.3%) |
| Dyslipidemia | 118(58.7 %) |
| Positive family history | 77(38.3%) |
| Renal dysfunction | 9 (4.48%) |
| H/O CVA | 6 (2.98%) |
| PVD | 1 (0.50) |
| Chronic Lung disease | 13(6.47%) |
| CCS- (I-II) | 61(30.35%) |
| CCS (III-IV) | 127(63.18%) |
| Dyspnea | 50(24.87%) |
| Previous PTCA (ISR) | 9(4.48%) |
| Failed PTCA | 5(2.45%) |
| Disease | |
| Lt. Main Disease (LMD) | 40(19.9%) |
| Single Vessel Disease (SVD) | 8(3.98%) |
| Double Vessel Disease (DVD) | 31 (15.42%) |
| Triple Vessel Disease (TVD) | 159 (79.1%) |
| LVEF (%) (Mean ± SD) | 49.2±17.6% |

MI: Myocardial Infarction, UA: Unstable Angina, CVA: Cerebrovascular Accident, PVD: Peripheral Vascular Disease, CCS: Canadian Cardiovascular Score, LVEF: Left Ventricular Ejection Fraction, PTCA: Percutaneous Transluminal Coronary Angioplasty. ISR: In Stent Restenosis.

**Table II** Intraoperative variables of patients undergone CABG

| Variables | Number of patients n=201 (%) |
|---|---|
| Conventional CABG | 176 (87.56%) |
| OPCABG | 25(12.44%) |
| MIDCABG | 2 (0.99%) |
| Conversion to ECC of OPCABG Patient | 2 (0.99%) |
| Distal anastomosis/ Patient | 2.78± 1.25 |
| Types of Conduit | |
| LIMA | 194 (96.52%) |
| Great Saphenous Vein (GSV) | 194 (96.52%) |

| Variables | Number of patients n=201 (%) |
|---|---|
| Bypassed arteries | |
| LAD | 193(96.02%) |
| With LIMA | 189 (94.02%) |
| With RSVG | 4 (2%) |
| Diagonal | 21 (10.45%) |
| Ramus Intermedius (RI) | 12 (5.97%) |
| OM | 163 (81.09%) |
| RCA/PDA | 166 (82.59%) |
| Others(PLB /RV Branch) | 2 (0.99%) |
| Number of grafts done | |
| CABG x 1 | 7 (3.48%) |
| CABG x 2 | 49 (24.38%) |
| CABG x 3 | 126 (62.69%) |
| CABG x 4 | 19 (9.45%) |
| CABG x 5 | 0 (0%) |
| Non graftable artery | |
| LAD | 1 (0.5%) |
| Marginal | 4 (2%) |
| RCA/PDA | 1(0.5%) |
| Aortic calcification/ Plaque | 8(3.98%) |
| Combined CABG + valve surgery | 2(0.99%) |
| MVR + CABG X 3 | 2 (0.99%) |
| AVR+CABG x 2 | 2(0.99%) |
| XCT min (Mean ± SD) | 70.73± 10.25 min |
| ECCT min (Mean ± SD) | 100.75± 9.15 min |

CABG: Coronary Artery Bypass Graft, OPCABG: Off-Pump Coronary Artery Bypass Graft, MIDCABG: Minimal Invasive Direct Coronary Artery Bypass Graft, LIMA: Left Internal Mammary Artery, LAD: Left Anterior Descending Artery, OM: Obtuse Marginal, RCA: Right Coronary Artery, PDA: Posterior Descending Artery, PLB: Posterior Left Ventricular Branch, XCT: Cross Clamp Time, ECCT: Extracorporeal Circulation Time.

**Table III** Perioperative outcome of patients of in CMCH

| Variables | Number of patients n=201 (%) |
|---|---|
| Mortality | 14 (6.96%) |
| Operatvie | 0 |
| Post-operative (Early) | 14 (6.96%) |
| Perioperative MI | 6(2.98%) |
| Intra Aortic Balloon Pump (IABP) | 1 (0.5) |
| Total Blood loss (ml/24 h) mean±SD | 325.2±20.4 |
| Re-exploration | |
| for bleeding | 7 (3.48%) |
| for others | 1 (0.5%) |
| Blood transfusion (Unit) mean±SD | 1.75±1.53 |
| Postoperative inotropes | 140 (69.65%) |
| Arrhythmias | |
| AF | 10 (4.97%) |
| SVT | 9 (4.48%) |
| VT | 4 (2%) |
| Others | 3 (1.49%) |
| Intubation time (h) mean±SD | 10.2 ±2.4 |
| Reintubation | 4 (2 %) |
| Prolonged ventilation | 7 (3.48%) |
| Stroke | 1 (0.5%) |
| Post cardiotomy Psychosis | 2 (0.99%) |
| Cardiac Temponade | 1 (0.5%) |
| Pulmonary complication | 12 (5.97%) |
| Post op- Pleural effusion require ICT | 4 (2%) |
| Wound infection | |
| Mediastinitis with/ without sternal dehisence | 1 (0.5%) |
| Leg wound infection | 8(4%) |
| Chest wound infection | 8 (4%) |
| DVT | 2 (0.99%) |
| Acute renal failure | 4 (2%) |
| ICU support in hours mean±SD | 48 ±8 |
| Hospital stay after CABG | 7 ± 4 |

MI: Myocardial Infarction, IABP: Intra-Aortic Balloon Pump, ICU: Intensive Care Unit, Post-op: Postoperative.

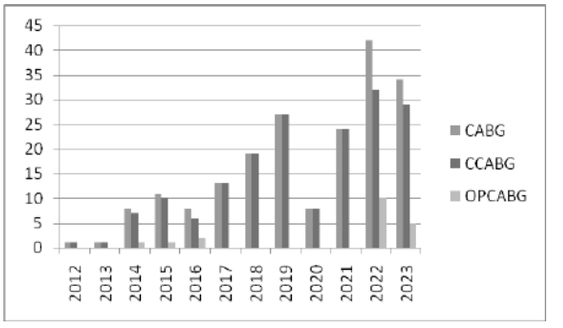


**Figure 1** Number of CABG done in different years

## Discussion

In our study, adult-onset diabetes affects 38%, hypertension 39%, and hypercholesterolemia nearly 58%, all higher than global rates of 24%, 26% and 48%.[11,12,13,14] These trends are driving the rising need for Coronary Artery Bypass Grafting (CABG) in Bangladesh. All our cases were accepted for surgery nonselectively as soon as it was referred from our cardiologist. Clopidegrol was stopped at least 5 days prior to elective procedures. Cardiac surgeons are faced with progressing higher risk challenging cases, only difficult cases not suitable to interventional

cardiology were referred to the surgeons. These included elderly patients with small vessels, multiple distal disease and poor left ventricular function. These will add to the difficulty facing new small cardiac units. The results of these 201 cases presented are, in general, good and encouraging as it is comparable to the local and international standards.[15] In the management of our patients, we have taken up many new modalities of treatment, which have proven clinical or experimental benefits. The use of blood cardioplegia is an expanding subject in cardiac surgery and many studies have documented its superiority over crystalloid cardioplegia. The use of epsilon-aminocaproic acids and Tranexamic acid helped in reducing the intraoperative and postoperative blood loss and need for blood transfusion.[16] Our future prospective will focus on expanding our open-heart workload, establishing a combined hybrid cardiology cardiac surgery service and starting a pediatric cardiac surgery program. We used intravenous magnesium sulfate in 1st POD to prevent post operative cardiac arrhythmias.[17]

The results of these cases presented here show equally good results to those of larger and longer established centers, either locally or internationally. In addition to the obvious convenience for patients and their relatives during elective treatment and follow-up in centers near their residence, the existance of these well distributed centers offers an invaluable part of care. The success of conducting such programs depends on local factors but also relies on the cooperation of other centers and referring institutes.

In the management of our coronary artery disease patients, we were conservative and have taken conventional techniques and procedures initially for this newly established center, which have proven clinical or experimental benefits. This retrospective review of prospectively collected data demonstrates that patients with ischemic heart disease with significant coronary artery stenosis can be revascularized safely in our newly constructed unit.

In our series the mean number of grfts was 2.78± 1.25 (Table-II) which is similar to other studies.[7,18,19] Although this is a small series and early experience, this observation is similar with other worker.[20] The incidence of complication in the reports particularly neurological, Peri opertive MI, in this new setup is lower. In our study we observed lower postopertive morbidity particularly blood loss, requirement of blood or blood products and atrial fibrillation. The ICU and hospital stay were shorter in this group. There was a definite trend toward improved in-hospital survival.

**Limitation**

The number of cases in this study is small, and while the demand for CABG surgeries is increasing globally, our new cardiac unit faced limitations in personnel and logistics, restricting the number of surgeries we could perform. In the future, we aim to increase surgical capacity and offer emergency CABG procedures.

**Conclusion**

Over recent years, advancements in cardiac surgery have led to improved CABG outcomes. In addition to CABG, our center performs various valvular, congenital and vascular procedures for both adults and children. However, challenges such as the absence of pediatric cardiologists, perfusionists, trained nurses and dedicated surgical wards, along with the impact of COVID-19, have limited operations. Despite this, we are steadily building surgical expertise and staff. Besides conventional CABG and OPCAB, we are preparing to offer MIDCAB procedures and aim to expand our open-heart surgery workload in the future.

**Recommendations**

Future studies could focus on outcomes in specific groups, like diabetics and the elderly, to improve treatment strategies. Comparative research between CABG and PCI for multivessel disease is crucial as PCI becomes more prominent. Minimally invasive and robotic CABG should be explored to assess benefits, risks, and costs. Postoperative care improvement and outcomes in high-risk populations, such as those with low ejection fractions or kidney disease, are essential areas for further investigation.

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**Contributions of authors**

MFM-Study design, data collection, data interpretation, drafting & final approval.

TA-Data interpretation, critical revision & final approval.

MAQC-Data collection, data interpretation, critical revision & final approval.

FWS-Data interpretation, data analysis, drafting & final approval.

AM-Data interpretation, data analysis, drafting & final approval.

MRC-Data interpretation, data analysis, drafting & final approval.

SB-Data interpretation, data analysis, drafting & final approval.

MHA-Data collectuion, drafting & final approval.

RNM-Data interpretation, drafting & final approval.

NH-Conception, critical revision & final approval.

**Disclosure**

All the authors declared no conflict of interest.

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