

# Evolution of Surgery for Coronary Artery Disease

Gurjit Singh, Arvind Kohli, Shyam Singh

Coronary artery disease is the leading cause of death all over the world. Myocardial revascularization is the commonest cardiac surgical procedure done today. Coronary artery bypass grafting (CABG), the most effective procedure for the management of coronary artery disease has evolved following multitude of innovative ideas and techniques utilized.

## Early attempts

Ischemic heart disease was evident in Egyptian mummies, the oldest human remains available. Alexis Carrel for the first time attempted myocardial revascularization in dogs in the beginning of 20th century, by joining descending aorta with the epicardial end of a coronary artery (1).

## Indirect Myocardial Revascularization

Claude S. Beck (2) in United States noticed that experimentally induced pericardial adhesions were quite vascular. In 1930, he used such procedures in animals and subsequently extended such procedures to clinical trials in 1935. In these operations, he abraded the epicardium and then attached either abraded pericardium or the pectoral muscle. Using this concept of revascularization, several modifications were tried by other surgeons, which include: cardio-omentopexy, cardiopneumopexy, cardiogastropexy, cardiojejunopexy and pedicled skin grafts (3,4).

Based on the concept introduced by Pratt (5) in 1898 (that reversal of flow in coronary sinus could increase myocardial blood flow) Roberts and Fauteux ligated the great cardiac vein and the coronary sinus in the experimental studies to increase myocardial blood flow (6,7).

Arthur Vineberg (8) in 1946 introduced internal mammary artery implantation into the myocardium. This

procedure led to the development of connections between IMA and the coronary arteries. This procedure became popular in USA and Canada in 1960's.

## Direct Coronary Artery Surgery

Direct attack on the blocked coronary arteries was made by Charles Bailey (9) *et. al.* and Longmaire (10) *et. al.* who reported endarterectomy of the coronary arteries without cardiopulmonary bypass in late 1950's. Effler (11) in 1964 reported coronary endarterectomy with a vein patch grafting using cardiopulmonary bypass.

PK Sen (12) in 1956 reported an experimental study of transmyocardial acupuncture which laid the basis of development of transmyocardial laser revascularization at a later date. Then came the era of direct coronary artery bypass surgery. Saphenous vein as a conduit was initially used by Sabiston (13) and Garrett, Dennis and Debakey (14) in early 1960's. Johnson (15) was one of the pioneer of coronary bypass surgery and he widely employed and popularized saphenous vein bypass grafting.

A major boost to direct coronary revascularization came with the development of cine coronary angiography by Sones and Shirey (16) at Cleveland clinic in 1962. Favalaro (17) from Cleveland clinic routinely used saphenous vein for bypass grafting.

In 1968, Green *et. al.* (18) reported use of internal mammary artery (IMA) for CABG using cardiopulmonary bypass. However CABG as we know it today happened in 1969 with the report of large series of CABG cases by W. Dudley Johnson and colleagues from Milwaukee (19). Green, Loop and others later popularized the use of IMA as conduit of choice with superior long term patency (20,21).

From the Department of Cardiothoracic & Vascular Surgery Unit, Govt. Medical College, Jammu J&K, India.

Correspondence to : Dr. Gurjit Singh, Assistant Professor & Head, CTVS Unit, Govt. Medical College, J&K, India.

Subsequent to above developments CABG became the most popular method of managing coronary artery disease all over the world, with very low morbidity and mortality.

#### **Total arterial revascularization**

Results of use of IMA as conduit were reported to be superior with more long term patency, reduced cardiac events and enhanced survival as compared to the use of only venous conduits. This led to the use of more and more arterial grafts. Bilateral IMA use was advocated but it required more operative time and increased morbidity in diabetics and elderly patients. It was followed by the use of other arterial grafts like radial artery by Carpentier *et. al.* (22) and right gastroepiploic artery by Suma *et. al.* (23). Hence the concept of total arterial revascularization became popular. (Calafiore *et. al.* (24).

#### **Trans myocardial laser revascularization**

The concept of trans myocardial revascularization was introduced by Sen and colleagues (12) in 1965. The advent of lasers inspired Mirhoseini and colleagues (25) to apply high power co2 laser for trans myocardial revascularization in selected cases where conventional grafting technique was not possible. TMLR has proved to be an important adjunct to CABG for complete myocardial revascularization.

#### **Off-pump coronary artery bypass grafting (OPCAB)**

Myocardial revascularization without cardiopulmonary bypass was initially described by Kolessov (26). However it was subsequently popularized by Buffolo *et. al.* (27), Laborde *et. al.* (28) Benetti *et. al.* (29) and Calafiore *et. al.* (30). This procedure could avoid all the deleterious effects associated with cardiopulmonary bypass while achieving good myocardial revascularization. Use of tissue stabilizers, cardiac positioners, intra coronary shunts, good quality instruments and loupes have made OPCAB a standard technique today. Initially started for single vessel disease, it is now being used for all cases requiring CABG, even multi-vessel disease.

#### **Newer modifications**

##### **Minimally invasive coronary artery bypass**

With the introduction of minimally invasive techniques in general surgery, attempts were made to

develop similar procedures for CABG. Avoidance of median sternotomy and CPB could make CABG less invasive. With this aim, the procedure of minimally invasive direct coronary artery bypass (MIDCAB) was introduced by Calafiore (30) and colleagues and by Acuff (31) and colleagues. In this procedure left internal mammary artery to left anterior descending anastomosis was made through a small left anterior thoracotomy. With the development of a closed chest CPB and cardioplegia system, almost all the coronary branches of the left ventricle can be exposed and grafted through small holes in the chest by the Heart Port technique. Endoscopic saphenous vein and radial artery harvesting and thoracoscopic IMA harvesting have made CABG simple and less traumatic (32,33).

##### **Robotic assisted coronary artery bypass**

A recent development in the field of cardiac surgery has been robotic assisted surgery. Robotic arms were initially used for LIMA harvesting but recently Da Vinci robotic system has made totally endoscopic robotic assisted CABG possible. Today CABG can be performed by computerized control of robotic arms. Many perceive it as the ultimate in the field of minimally invasive CABG (34,35). Amongst the recent introductions are the newer technologies for performing proximal and distal anastomosis precisely and in lesser time (36,37).

##### **Gene therapy**

The introduction of gene therapy and genomic strategies for cardiovascular surgery have further changed the outlook towards the surgical management of coronary artery disease (38). Newer developments are taking place every day and at what juncture will the surgical management of coronary artery disease be at the end of the century is unimaginable.

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