Anesthetic Management for Coronary Artery Surgeries Undergone Without Cardiopulmonary Bypass

An Essay

Submitted for partial fulfillment for the Master Degree In Anesthesiology

By

Ahmed Mahmoud Hany Mohamed Ayoub

MB,B.,ch

Supervised by

Prof. Dr. Yehia Abd El Rehim Hememi

Professor of Anesthesiology and ICU

Faculty of Medicine - Ain Shams University

Prof. Dr. Omar Mohamed Taha El Safty

Assistant Professor of Anesthesiology and ICU

Faculty of Medicine - Ain Shams University

Dr. Shreen Kamal Zaki Kodira

Lecturer of Anesthesiology and ICU

Faculty of Medicine - Ain Shams University

Faculty of Medicine

Ain Shams University

٢٠٠٥

ACKNOWLEDGMENT

All thanks to Allah who helps us to pass through the difficulties in our lives and who helped me to accomplish this work.

I am deeply grateful to **Prof. Dr. Yehia Abd El Rehim Hememi** Professor of Anesthesiology and ICU Faculty of Medicine-Ain Shams University for sponsoring this work, his superb leadership, keen supervision and wise counsel throughout this work.

I am also greatly indebted and extremely grateful to **Prof. Dr. Omar Mohamed Taha El Safty** Assistant Professor of Anesthesiology and ICU Faculty of Medicine-Ain Shams University for his continuous supervision, encouragement, invaluable assistance and guidance step by step till this essay was finished.

The invaluable help, fruitful advice and continuous support offered to me by **Dr. Shreen Kamal Zaki Kodira** Lecturer of Anesthesiology and ICU Faculty of Medicine - Ain Shams University can never be estimated, my deepest gratitude to her.

I'd like also to thank every one who had helped me to finish this work.

Contents

List of Tables

List of Figures

List of Abbreviations

AF	Atrial fibrillation
AMP	Adenosine mono-phosphate
APTT	Activated partial thromboplastin time
ARDS	Adult (Acquired) respiratory distress syndrome
ATP	Adenosine triphosphate
AV	Atrioventricular
CABG	Coronary artery bypass grafting
CAD	Coronary art. Disease
cAMP	Cyclic adenosine mono-phosphate
CaO_2	Arterial O_2 content
CBF	Coronary blood flow
cGMP	Cyclic guanidine mono-phosphate
CHF	Congestive heart failure
CK-MB	Creatine kinase- Myoglobin
CNS	Central nervous system
COP	Cardiac output
CPB	Cardio pulmonary bypass
Cr post cl	Postoperative creatinine clearance
Cr pre cl	Preoperative creatinine clearance.
D Cr Cl	Perioperative change in creatinine clearance
DA	Dopamine
FENa	Fractional excretion of sodium
GMP	Guanidine mono-phosphate
HEP	High energy phosphate
HR	Heart rate
IL	Interleukin
INR	International normalization ratio
LA	Left atrium
LAD	Left anterior descending coronary artery
LCx	Left circumflex coronary artery
LMCA	Left main coronary artery
LMWH	Low molecular weight heparin
LV	Left ventricle
LVEDP	Left ventricular end-diastolic pressure
LVEDV	Left ventricular end-diastolic volume
MAC	Minimum alveolar concentration
MIDCAB	Minimally invasive direct- access coronary artery bypass

MOF	Multiple organs failure
MPG	N-٢- Merca ptopropiongl glycise
NAG	N- acetyl-[beta]- D- glucosaminidase
NO	Nitric oxide
OPCAB	Off-pump coronary artery bypass
PAF	Platelet- activating factor
PCWP	Pulmonary capillary wedge pressure
PG	Prosta glumdins
RA	Right atrium
RCA	Right coronary artery
RV	Right ventricle
SA	Sino-atrial
SIRS	Systemic inflammatory response syndrome
SOD	Supenoxide dismutase
TNF	Tumor necrosing factor-Alpha

INTRODUCTION

Coronary artery bypass grafting (CABG) is one of the most commonly performed cardiac surgical procedures. In the last decade, there has been renewed interest in performing CABG without cardiopulmonary bypass (CPB) **(Chassot et al., ٢٠٠٤).**

Off-pump coronary revascularization is an old technique, performed first in St Petersburg in ١٩٦٤ **(Kolessov, ١٩٦٧),** but was soon outshone by the rapid development of CPB and cardioplegia.

Cardiopulmonary bypass has the advantage of providing the surgeon with an immobile heart in a near bloodless field. In the modern era of cardiac surgery, CPB can be undertaken with a greatly decreased morbidity and mortality, but is nevertheless associated with significant clinical and subclinical tissue and end-organ injury. Cardiopulmonary bypass results in the development of inflammation, a coagulopathy and central nervous system complications. The whole body inflammatory response is due to the bioincompatibility of the CPB circuit **(Kirklin, ١٩٩١).**

The humoral and cellular components of blood are activated, with resultant damage to cellular membranes throughout the body. In addition, coagulopathy occurs with platelet dysfunction, accelerated fibrinolysis and the consumption of clotting factors **(Royston, ١٩٩٠).**

The blood flow delivered during CPB may also be unphysiological. Many surgeons still do not use pulsatile perfusion and even when it is used; it may not deliver the same quality of perfusion as native pulsatile flow. This may become critically important in patients who are at risk, such as hypertensive patients, arteriopaths and diabetics with small vessel arteriopathy. Organ injury has been described in the brain, lungs, kidneys and splanchnic bed. Of these, neurological injury is often the most deleterious, impacting on both short-term and long-term quality of life **(Roach et al., ١٩٩٦).**

Avoiding CPB eliminates aortic cannulation and cross-clamping, and is expected to reduce systemic inflammatory response, coagulation disorders, and multiple organ dysfunctions **(Chassot et al., ٢٠٠٤).**

A revival of the technique occurred during the ١٩٨٠s in isolated series, and in centers where limited resources favored off-pump techniques **(Chassot et al., ٢٠٠٤).**

The recent introduction of sophisticated stabilizing devices and exposure techniques has resulted in an increased graft patency rate, and in the widespread use of this technique for all coronary territories and for as many anastomoses as needed to treat the patient's coronary artery disease **(Calafiore et al., ١٩٩٨).**

Surgical advances that have been made in recent years include techniques of cardiac displacement, effective local cardiac wall stabilisation and the use of intracoronary shunts. Cardiac displacement allows the exposure of posterior, lateral and inferior targets and can be achieved either by the placement of deep pericardial retraction sutures or the use of stockinet sutured into the oblique sinus. Traction on the sutures or stockinet rotates and vertically displaces the heart out of the pericardial sac, allowing surgery to take place **(Heames et al., ٢٠٠٢).**

The key to successful off-pump coronary bypass grafting is effective local cardiac wall stabilisation, which allows good quality anastomotic suturing. Stabilisers placed on the epicardium over the planned site of arteriotomy reduce cardiac motion **(Stanbridge and Hadjinikolaou, ١٩٩٩).**

Several stabilizers have gained acceptance and studies relating to their use have shown graft patency similar to that of conventional bypass **(Subramanian, ١٩٩٧).**

The Octopus stabilisation system (Medtronic Inc., Minneapolis, USA), which consists of two paddles with four or five suction domes, is illustrated (Figs ١ and ٢). When suction is applied via the domes, the surgical field between the two paddles is immobilized **(Kappert et al., ١٩٩٩).**

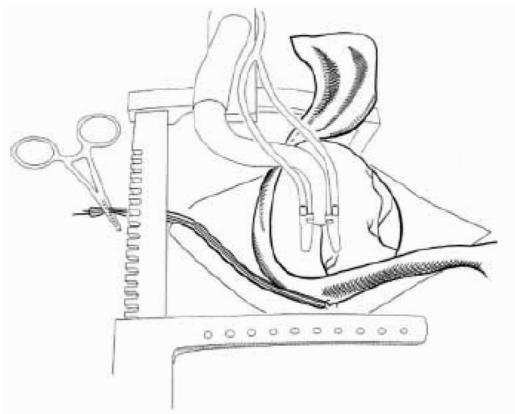

FIGURE ١: The Octopus retractor adjacent and parallel to the arteriotomy site **(Heames et al., ٢٠٠٢).**

One advantage of the Octopus system over other stabilizing systems is that it lifts the anastomotic site as opposed to depressing the site, which can impair ventricular filling **(Nierich et al., ١٩٩٩).**

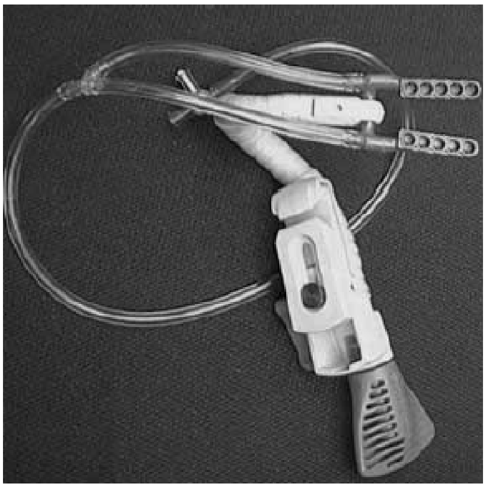

FIGURE ٢: The Octopus stabilization system (Medtronic Inc., Minneapolis, USA) **(Heames et al., ٢٠٠٢).**

Off pump coronary artery surgery has been developed following two different approaches. Minimally invasive direct-access coronary artery bypass (MIDCAB) consists of anastomozing the left internal mammary artery to the left anterior descending coronary artery through a small anterior left thoracotomy. Nowadays, this technique has largely been abandoned, because it allows only single vessel surgery, is technically demanding, and may lead to suboptimal results.

Moreover, postoperative pain is usually more severe after thoracotomy than after sternotomy **(Diegeler et al., ١٩٩٩).**

The second approach is multivessel grafting without CPB performed through a standard median sternotomy, which gives access to all coronary vessels, and allows standard techniques of mammary artery harvesting **(Chassot et al., ٢٠٠٤).**

This review will focus exclusively on the latter procedure, called off-pump coronary artery bypass (OPCAB) **(Chassot et al., ٢٠٠٤).**

ANATOMICAL and PHYSIOLOGICAL CONSIDERATIONS

Functional anatomy of the heart

The heart can be considered as two parallel pumps, each consisting of an atrium and a ventricle, acting in unison to propel blood into the pulmonary and systemic circulations from the right and left sides, respectively. Anatomically, the walls of the cardiac chambers consist of three parts: the endocardium, a thin inner layer of endothelial cells in direct contact with the blood; the myocardium, a middle layer consisting predominantly of muscle tissue; and the epicardium, an outer layer that is actually the inner portion of the double-layered pericardium, a fibrous sheath composed of mesothelial cells encasing the heart **(Miller, ٢٠٠٠).**

Blood return from the body enters the right atrium (RA) through the superior and inferior vena cava. It is then pumped through the tricuspid valve into the right ventricle (RV) and through the pulmonic valve into the pulmonary circulation, where oxygen–carbon dioxide exchange occurs within lung alveoli. Newly oxygenated blood returns to the left atrium (LA) via the pulmonary veins and passes through the mitral valve into the left ventricle (LV). The blood is then propelled through the aortic valve into the systemic circulation in order to meet the metabolic demands of peripheral tissues. Elaborate nervous and endocrine feedback loops carefully regulate the function of the heart and circulatory systems **(Miller, ٢٠٠٠).**

Anatomy of coronary arteries

From the anatomic point of view, the coronary artery system divides naturally into two distributions, left and right. From the stand point of the surgeon, the coronary artery system is divided into four parts: the left main coronary artery (LMCA), the left anterior descending coronary artery (LAD) and its branches, the left circumflex coronary artery (LCx) and its branches, and the right coronary artery (RCA) and its branches. The branches of each of the last three vessels must also be known **(Kouchoukos et al., ٢٠٠٣).**

The major coronary arteries form a circle and a loop around the heart. The circle is formed by the right coronary and left circumflex arteries as they traverse the atrioventricular sulci. The loop between the ventricles and at right angles to the circle is formed by the LAD and the posterior descending coronary artery as they encircle the septum **(Daves, ١٩٧٠).**

The blood supply to the back of the left ventricle streams down as a series of parallel obtuse marginal arteries coming from the posterior half of the circle, formed on the left by the LCx and on the right (in hearts with a dominant right coronary circulation) by the extension of the RCA across the crux cordis, the area along the posterior aspect of the atrioventricular groove where the atrial and ventricular septa meet, termed the right postrolateral segment. This latter segment supplies inferior surface (marginal) branches to the inferior (diaphragmatic) surface of the left ventricle (**Kouchoukos et al., ٢٠٠٣).**

Although the RCA may not supply a large portion of the posterior left ventricular wall, it nevertheless serves the left side of the heart to a greater extent than it does the right side in terms of the number and volume of vessel segments involved. A right dominant artery does not necessarily supply branches to the inferior surface of the left ventricle, however, because it may terminate only as the posterior descending artery **(Zamir, ١٩٩٦).**

The blood supply to the anterior portion of the left ventricle comes from the diagonal branches of this portion of the loop, the LAD. That to the lateral part of the anterior portion comes from the first branches of both the LAD and Cx arteries. The ventricular septum receives its blood supply from the loop that encircles it, formed by the LAD in front and the posterior descending artery behind **(Kouchoukos et al., ٢٠٠٣).**

Variability in the origin of the posterior descending artery is expressed by the term *dominance*. A right dominant coronary circulation is one in which the posterior descending coronary artery is a terminal branch of the RCA. A left dominant circulation, which occurs in about ١٠% to ١٥% of hearts, is one in which the posterior descending coronary artery is a branch, usually the last one, of the LCx. Left dominance occurs more frequently in males than in females. This distinction as to whether the right or left coronary artery supplies the posterior descending artery is important in evaluating patients with coronary artery disease and in the planning of coronary artery bypass grafting **(Kouchoukos et al., ٢٠٠٣).**

The following is a general description of coronary artery anatomy in normal hearts.

Some congenital cardiac malformations are associated with abnormalities of the coronary arteries. The nomenclature is based on the

United States National Heart, Lung, and Blood Institute's Proposal and *Manual of Operations for Collaborative Studies in Coronary Artery Surgery* and The American Heart Association's coronary artery disease reporting system. Both systems include rules for defining the various segments of the major coronary arteries.

LEFT MAIN CORONARY ARTERY (LMCA)

The LMCA extends from the ostium in the left sinus of Valsalva to its bifurcation into the LAD and LCx branches. Its usual length is ١٠ to ٢٠ mm, with a range of ٠ to ٤٠ mm. It normally courses between the pulmonary trunk and the left atrial appendage to reach the left atrioventricular groove. Occasionally, additional vessels originate from the LMCA and course parallel to the diagonal branches of the LAD branch. Such an additional artery (formerly called a *ramus intermedius*) is termed the *first diagonal branch* of the LAD. Rarely (in ١% of persons), the LMCA is absent, the LAD and LCx arteries originating directly from the aorta via separate ostia **(James, ١٩٦١).**

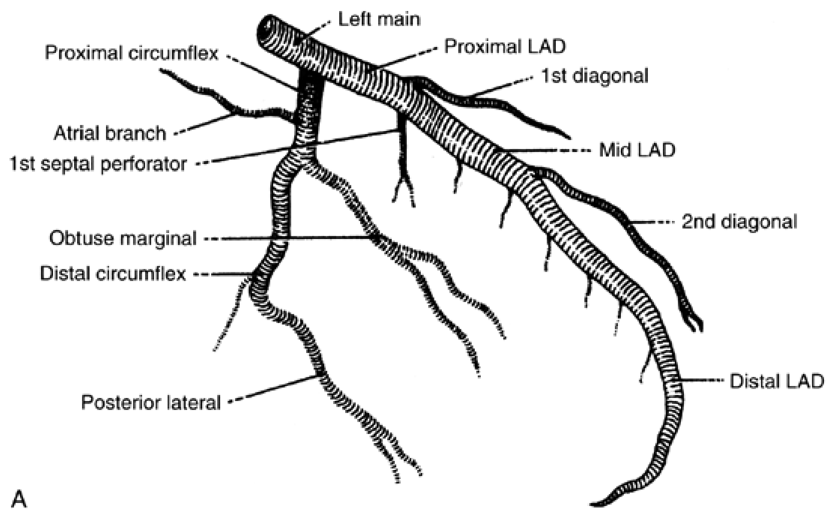

FIGURE ٣-A: Anatomy of the left and coronary artery showing the nomenclature recommended by the American Heart Association. LAD left anterior descending **(King and Douglas, ١٩٧٨).**

LEFT ANTERIOIR DESCENDING CORONARY ARTERY (LAD)

Beginning as a continuation of the LMCA, the LAD artery courses along the anterior interventricular sulcus to the apex of the heart. Part of it may be buried in muscle. In most cases, this artery extends around the apex into the posterior interventricular sulcus, supplying the apical portion of both right and left ventricle. This vessel supplies branches to the right ventricular free wall (usually small), to the septum, and the left ventricular free wall. One or more branches to the right ventricle connect with infundibular branches from the proximal RCA. This important route for collateral flow is the *loop of Vieussens*.

The *septal arteries* arise almost perpendicularly from the LAD, a characteristic that is sometimes helpful in the angiographic identification of the LAD. A variable number of diagonal arteries course obliquely between the LAD and the LCx arteries and supply the left ventricular free wall anteriorly and laterally **(Baltaxe, et al., ١٩٧٣).**

Variations in the LAD are infrequent, although in about ٤% of hearts, it exists as two parallel vessels of about equal size. It may terminate before the apex or extend as far as the posterior atrioventricular groove **(Baltaxe, et al., ١٩٧٣).**

LEFT CIRCUMFLEX CORONARY ARTERY (LCx)

The LCx originates from the LMCA at about ٩٠° angle, with its initial few centimeters lying medial to the base of the left atrial appendage. The sinus node artery occasionally originates from the first few millimeters of the LCx. Rarely the LCx terminates before the obtuse margin. A large branch originating from the proximal LCx and coursing around the left atrium near the atrioventricular groove is termed the *atrial circumflex artery*.

The ventricular branches of the LCx, the *obtuse marginal arteries*, supply the obtuse margin of the heart and may be embedded in the muscle. Often, their position can then be identified at operation by the altered color (reddish or light tan) of the overlying thin muscle layer compared with that of the remainder of the ventricular wall. Those branches supplying the inferior surface of the left ventricle in a heart with a left dominant system (or in one with a codominant system in which the RCA gives rise only to a posterior descending artery) are termed *left posterolateral* (marginal) *arteries*. In hearts with a left dominant system, the LCx gives rise to the *posterior descending artery* at or usually before the crux. Variations in the origin and the length of the LCx, and in number and size of its marginal branches, are common **(Gensini, ١٩٧٥).**

RIGHT CORONARY ARTERY (RCA)

The RCA usually is a single large artery, and it courses down the right atrioventricular groove. Branches supplying the anterior right ventricular free wall exit from the atrioventricular sulcus in a looping fashion because of the depth of the RCA in the sulcus. In this same area, the anterior right atrial artery arises, and this branch often gives origin to the sinus node artery. More distally, a lateral right atrial artery usually arises (this artery is frequently severed when an oblique right atriotomy is made) **(Busquet et al., ١٩٨٤).**

In the region of the acute margin of the heart, a relatively constant long branch of the RCA arises, the *acute marginal artery*, which courses most of the way to the apex of the heart.

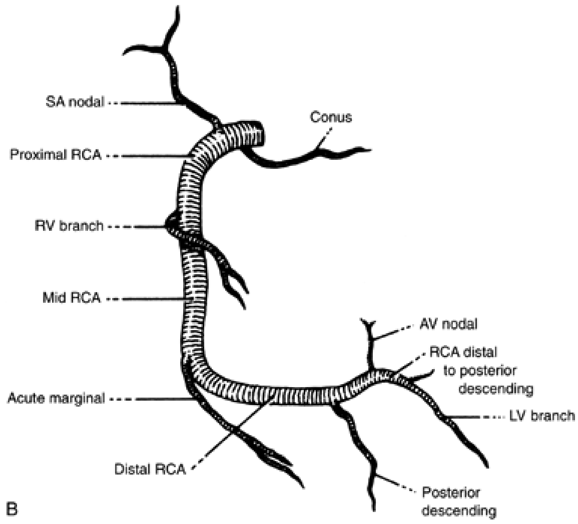

FIGURE ٣-B: Anatomy of the right coronary artery showing the nomenclature recommended by the American Heart Association. SA, sinoatrial; RCA, right coronary artery; AV, atrioventricular; LV, left ventricular **(King and Douglas, ١٩٧٨).**

The RCA in most hearts crosses the crux, where it takes a characteristic deep U-turn, giving off the *atrioventricular node artery* at the apex of the turn. The RCA then terminates by bifurcating into the *right posterior descending coronary artery* and the *right posterolateral segmental artery*. The *posterior descending coronary artery* descends in the posterior interventricular sulcus for a variable distance, giving rise to septal, right ventricular, and left ventricular branches. Variations in its anatomy are numerous, and it frequently arises before the crux. The right