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Coronary Artery Bypass Surgery: A Narrative Review

Koroner Arter Bypass Cerrahisi: Derleme

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Abstract

Coronary artery bypass surgery has remained the gold standard of coronary revascularization for many years in many patients with coronary artery disease, especially in patients with multivessel coronary artery disease. In this paper, basic information, history and indications related to coronary bypass surgery, as well as preoperative, operative and postoperative approaches and complications are concisely reviewed in the light of current literature and presented to the readers.

Keywords: Coronary Artery Bypass Surgery; Coronary Artery Disease, Review.

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Öz

Koroner arter bypass cerrahisi, uzun yıllardan beri çoklu damar koroner arter hastaları başta olmak üzere, koroner arter hastalığı olan birçok hastada koroner revaskülarizasyonun altın standardı olma özelliğini devam ettirmektedir. Bu makalede, koroner bypass cerrahisi ile ilişkili temel bilgiler, tarihçe ve endikasyonların yanı sıra preoperatif, operatif ve postoperatif yaklaşımlar ve komplikasyonlar güncel literatür ışığında gözden geçirilerek kısa ama özlü bir şekilde derlendi ve okuyuculara sunuldu.

Anahtar Kelimeler: Koroner Arter Bypass Cerrahisi; Koroner Arter Hastalığı, Derleme

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Introduction

Coronary artery disease (CAD) is a common spectrum of conditions that occurs when blood flow to the myocardium is partially or completely blocked due to narrowing or obstruction of the coronary arteries. CAD is a leading cause of death in developed countries, accounting for approximately one-third of all deaths (1,2). Although it has begun to be seen at younger ages in recent years, the disease primarily affects individuals over the age of 40. Due to the protective effect of estrogen in women, CAD is more frequently observed in men than in women. The disease is commonly seen in men between the ages of 50 and 60, while in women, it most often affects those aged 60 to 70 (3). The main factor contributing to the etiopathogenesis of CAD is "atherosclerosis" (4).

Understanding the risk factors that lead to this disease and taking preventive measures are as important as treating the disease itself. CAD risk factors are divided into two groups: non-modifiable risk factors (genetic predisposition, advanced age, gender) and modifiable risk factors (hypertension, diabetes, hyperlipidemia, smoking, stress, obesity, sedentary lifestyle) (2).

The main treatment methods for CAD include risk modification and medical therapy, percutaneous coronary interventions, and coronary bypass surgery (2,5).

Coronary artery bypass surgery is a surgical treatment aimed at reperfusing coronary arteries that are not adequately perfused due to narrowing or obstruction, thereby restoring their functionality. In this procedure, coronary reperfusion is achieved by bypassing occluded or narrowed coronary arteries through various autologous grafts anastomosed distal to the bypass (6).

History

In the early 1900s, Alexis Carrel performed the first experimental coronary artery bypass surgery on dogs. In 1956, Bailey successfully performed coronary endarterectomy, leading to direct surgical interventions on coronary arteries. In the early 1960s, Sabiston and Garrett published the first case reports of coronary bypass surgeries using the saphenous vein graft (SVG). In 1968, Favaloro reported successful coronary bypass surgeries utilizing the SVG. Prior to the SVG, the internal thoracic artery (ITA) was considered as a graft option. In 1961, Kolesov performed the first coronary bypass surgery using the ITA in Russia. In 1968, Green published the first case series of coronary bypass surgery using the ITA. Following Green's successful outcomes, the ITA became widely used worldwide as a bypass graft (7).

Indications

Individuals being evaluated for coronary artery bypass surgery should be assessed using the Society of Thoracic Surgeons (STS) risk classification. In patients with multi-vessel CAD, tools such as the SYNTAX (Synergy Between PCI with TAXUS and Cardiac Surgery) score can help in evaluating CAD complexity to guide revascularization decisions.

Class I indications for coronary artery bypass surgery are as follows:

1. Stenosis of more than 50% in the left main coronary artery

2. More than 70% stenosis in the proximal left anterior descending (LAD) and proximal circumflex arteries

3. Three-vessel disease in asymptomatic patients or those with mild or stable angina

4. Three-vessel disease with proximal LAD stenosis in patients with impaired left ventricular function

5. Stable angina and one- or two-vessel disease with a large viable myocardial area at high risk

6. Proximal LAD stenosis in patients with an ejection fraction (EF) of less than 50% or more than 70%, with ischemia demonstrated on non-invasive testing (8-10).

Other indications for coronary bypass surgery include:

1. Angina pectoris resistant to medical therapy

2. Persistent ischemia in the presence of non-ST elevation myocardial infarction (NSTEMI) unresponsive to medical treatment

3. The presence of viable but dysfunctional myocardium that can be revascularized in patients with low EF

4. Situations where percutaneous coronary intervention (PCI) is not feasible or has failed, and ischemia and pain continue to threaten a significant area of the myocardium despite medical therapy (8-10).

Preoperative Preparation

Before coronary artery bypass surgery, the patient's medical history should be carefully reviewed for factors that may predispose them to perioperative complications. If possible, these factors should be addressed, and the patient's medical condition should be optimized. Factors that may increase the risk of perioperative complications include recent myocardial infarction (MI), a history of previous heart surgery or chest radiation, conditions predisposing to bleeding (such as anticoagulant or antiplatelet use), renal and/or hepatic insufficiency, carotid artery disease, a history of cerebrovascular disease including transient ischemic attacks (TIA), electrolyte imbalances that may predispose the patient to arrhythmias, infections including urinary tract infections, skin infections, and dental abscesses, as well as respiratory dysfunctions such as chronic obstructive pulmonary disease (COPD) or lung infections.

Routine preoperative evaluations should include a complete blood count, coagulation profile, electrolyte levels, comprehensive biochemical analysis including kidney and liver function tests, chest radiography, electrocardiography (ECG), echocardiography, coronary angiography, and, if possible, carotid Doppler ultrasonography and epiaortic ultrasonography (11,12).

Surgical Approach

The most commonly performed method worldwide and in our country is standard coronary artery bypass surgery using cardiopulmonary bypass (heart-lung machine) and cardioplegic arrest (stopping the heart with solutions called cardioplegia). In this method, following a median sternotomy, arterial cannulation is performed from the ascending aorta and venous cannulation from the right atrial appendage, initiating cardiopulmonary bypass. Then, a cardioplegia solution is administered to stop the heart and temporarily protect the myocardium. During these steps, the bypass grafts are prepared concurrently. The most commonly used grafts are the internal thoracic artery (ITA), saphenous vein graft (SVG), and radial artery (RA). Aorto-coronary bypasses are generally completed by first performing distal coronary anastomoses, followed by proximal aortic anastomoses (13).

Off-pump coronary bypass surgery is performed with using some devices such as Octopus tissue stabilizer on the beating heart without cardiopulmonary bypass support. This surgical technique has been developed in order to avoid detrimental effects of cardiopulmonary bypass such as systemic inflammatory response. Thus, off-pump coronary bypass surgery has been reported to be associated with superior early-term postoperative outcomes to conventional coronary artery bypass surgery using cardiopulmonary bypass (14-16).

Other, less frequently used methods in coronary bypass surgery include beating heart coronary bypass surgery with cardiopulmonary bypass support, and coronary bypass surgery using minimally invasive, endoscopic, and robotic methods, which have gained popularity in recent years (17,18).

Postoperative Management

After the surgery, patients are admitted to the intensive care unit (ICU) and closely monitored with intubated mechanical ventilation support during the critical initial postoperative hours. During these critical hours, continuous monitoring is conducted to track arterial blood pressure, central venous pressure, blood oxygen saturation, heart rate, and rhythm. Blood gases are frequently checked to monitor oxygen, carbon dioxide, and saturation levels, as well as hemoglobin-hematocrit levels, blood pH, lactate, and electrolyte levels. Additionally, drainage output and urine output are carefully monitored. Hemodynamic parameters are maintained as stable as possible, and if necessary, fluid-electrolyte therapies and inotropic support are provided.

Patients who are hemodynamically stable, have minimal drainage, and show adequate wakefulness with normal motor function and neurological assessments are extubated within the first 4-6 hours postoperatively, discontinuing mechanical ventilation support. Patients without significant complications in the following monitoring are mobilized on the first postoperative day and transferred to the ward, where oral medication therapy is initiated (11,15,16).

Complications

Following coronary artery bypass surgery, a range of complications can occur both in the short and long term. These complications may be associated with anesthesia, cardiopulmonary bypass, incisions, and the surgery itself. The most common complications include myocardial dysfunction (perioperative MI, low cardiac output syndrome), cerebrovascular accidents (stroke, transient ischemic attack), bleeding and cardiac tamponade, acute renal failure, infections (pneumonia, mediastinitis, surgical wound infections), and arrhythmias (atrial fibrillation) (19,20).

In the early postoperative period, a temporary and mild decrease in myocardial function is expected due to myocardial edema and ischemia-reperfusion injury. However, additional factors such as incomplete revascularization or graft failure can exacerbate this mild dysfunction. Low cardiac output syndrome, which requires the use of inotropes and/or intra-aortic balloon pumps, occurs in approximately 4-9% of patients, while more severe cases, such as segmental transmural MI, occur in 1-5% of patients (21-23).

Cerebrovascular and neurological adverse events are significant concerns in cardiac surgery. Major events, such as stroke, occur in 1-4% of patients and can increase mortality by up to 10-fold. Embolisms from aortic cannulation and manipulations, microemboli from cardiopulmonary bypass, and low blood flow and hypoperfusion, particularly in individuals with chronic ischemic (relatively) brains (e.g., elderly patients), are responsible for these neurological events (24,25).

Postoperative renal failure is a critical cause of mortality following coronary artery bypass surgery. The incidence of acute renal failure in these patients is approximately 4%, and around 20% of these patients require hemodialysis. The mortality rate for those requiring hemodialysis postoperatively is reported to be about 50% (26).

Atrial fibrillation is also one of the most common complications after coronary artery bypass surgery, occurring in 10-40% of patients, usually on the 2nd or 3rd day post-surgery. Postoperative atrial fibrillation is associated with increased mortality, morbidity, and healthcare costs both in the short and long term (27-30).

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