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The future of minimally invasive cardiac surgery

By Victoria A. Kark, RN, CCNS, CCRN, MSN

Coronary artery bypass graft (CABG) has been the preferred standard of surgical treatment for coronary artery disease since the early 1970s. Over the years, refinements in intubation, cardioplegia, and extracorporeal circulation have improved its overall success rate to approximately 99%.[1] Less invasive and traumatic forms of heart surgery have rapidly increased, and have led to several minimally invasive heart surgery procedures. While current research hasn't been able to identify which procedure is best, many new options are available for patients with coronary heart disease.

Preoperative phase

The phase of surgery is a time of great stress and anxiety. The fear of pain, anesthesia, and death are frightening to both patients and their loved ones, and in most cases, go unspoken to healthcare professionals. It's important to assess the patient and family for stress-associated disorders using concepts from crisis intervention. Treating the patient and his or her family in a holistic manner is crucial during this period.

The nurse should assure that required forms, such as the surgical consent, history and physical examination, and preprocedure/preoperative surgical checklist, are complete and signed. The results of preprocedure laboratory tests should be available in the medical record. Any values outside of the normal range should be brought to the physician's attention. In addition, the nurse should be able to answer questions posed by the patient or family members. Patient and family education is geared to the next immediate steps in patient care, and should include crucial information needed during this highly stressful period.

The family also requires support during this time, with the focus being placed on anxiety management and the competence of the surgical staff. Open, honest, and timely communication with the family regarding the patient's condition is comforting, and provides a good opportunity for the healthcare team to assess the family's ability to learn and process information. This family communication not only helps to decrease

misunderstandings, but fosters a trusting relationship.

While the family is waiting for their loved one, basic comforts such as a nearby waiting room, a place to rest for family members who themselves aren't in the best of health, and restroom facilities that are convenient to the area are necessary. Moreover, the family should be encouraged to share any information that might assist with caring for the patient perioperatively.

During the preoperative phase, basic needs such as the right to privacy, relief from pain or anxiety, and safety issues are paramount. The use of relaxation techniques such as guided imagery, meditation, and prayer have been incorporated by many cardiac surgery programs with great success and positive patient satisfaction results.[2]

Surgery overview

CABG decreases the overall mortality of coronary heart disease, improves the functional status of patients, and provides relief from angina. Many patients report an improvement in quality of life because of a decreased need for pharmacologic therapy, and a reduction in the frequency of interventional procedures. CABGs experience a patency rate on average of 20 years (see *Coronary artery bypass grafts*).

Indications for CABG were first defined by the results of the Coronary Artery Surgery Study (CASS).[3] The study was performed by cardiothoracic surgeons and cardiologists in the early days of bypass surgery. Results demonstrated a survival advantage for patients undergoing surgery who had disease of the left main coronary artery, disease of all three major coronary arteries, and patients with left ventricular dysfunction.[3]

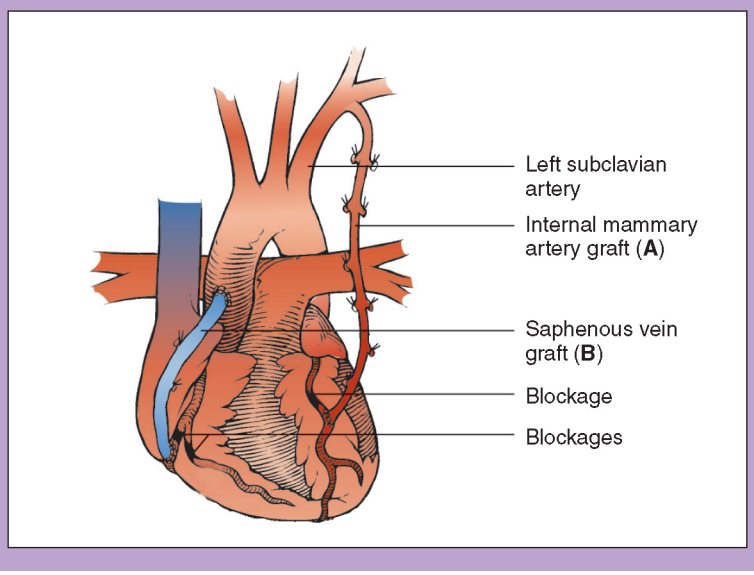
In general, cardiac surgery is indicated for patients who have significant stenosis of the left main coronary artery, severe anginal symptoms unresponsive to all other therapies, and stenoses in three coronary arteries with an ejection fraction of less than 50%.[4] Patients who fail percutaneous coronary intervention (PCI) or those with lesions that are too numerous or inaccessible to revascularization with PCI are also appropriate candidates. Other indications include younger patients who have small coronary arteries and need several bypasses, or patients whose heart won't tolerate being manipulated during the procedure. Coronary artery bypass grafting performed on a beating heart is still considered technically more difficult than surgery on a nonbeating heart.

Advantages and disadvantages

Traditional or conventional CABG surgery is performed with the assistance of cardiopulmonary bypass (CPB). (See *Cardiopulmonary bypass (CPB) system*.) Over the last 50 years, extracorporeal circulation has evolved into a safe means of providing systemic perfusion during open heart surgery. CPB may be of particular advantage for patients with heart failure, cardiomegaly, or acute myocardial infarction. Patients who have coronary arteries that are more technically difficult to bypass or have an inaccessible location, particularly on the posterior surface of the heart, are also good candidates. CPB diverts blood from the heart, removes carbon

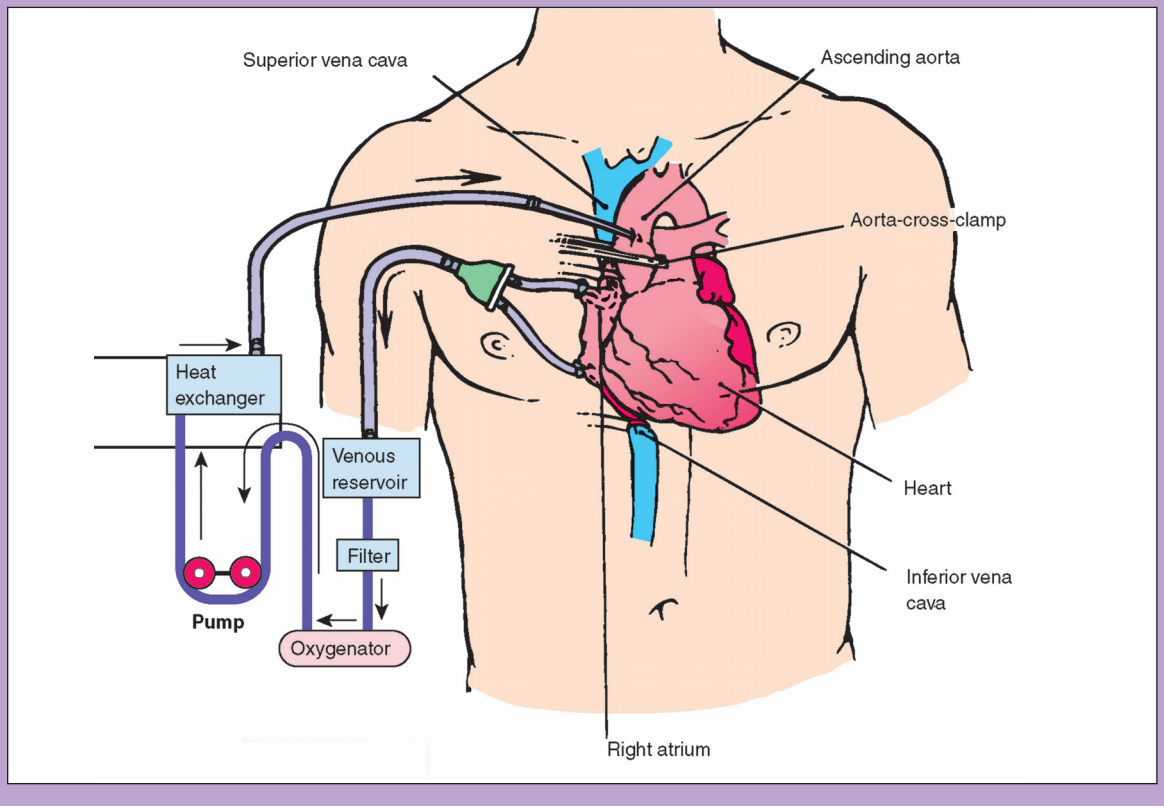
Coronary artery bypass grafts[12]

One or more procedures may be performed using various veins and arteries. (A) Left internal mammary artery, used frequently because of its functional longevity. (B) Saphenous vein, also used as bypass graft.



Cardiopulmonary bypass (CPB) system[12]

The cardiopulmonary bypass (CPB) system, in which cannulas are placed through the right atrium into the superior and inferior vena cavae to divert blood from the body and into the bypass system. The pump system creates a vacuum, pulling blood into the venous reservoir. The blood is cleared of air bubbles, clots, and particulates by the filter and then is passed through the oxygenator, releasing carbon dioxide and obtaining oxygen. Next, the blood is pulled to the pump and pushed out to the heat exchanger, where its temperature is regulated. The blood is then returned to the body via the ascending aorta.



dioxide from the blood, oxygenates it, and returns it to the body. Cardioplegia is instilled into the coronary circulation, which causes cardiac arrest so that the surgeon can operate on a motionless and blood free surgical field.[4]

While traditional CABG surgery using extracorporeal bypass has many benefits, it isn't without complications. Negative outcomes of the procedure fall into distinct major categories, including cardiovascular, hematologic, renal, pulmonary, and neurologic insult. One of the most significant complications is the inability to wean the patient from CPB. This is regarded as one of the more complicated sequences during cardiac surgery, since the patient's heart must resume responsibility for electrical as well as mechanical activity. Assist devices such as the intra-aortic balloon pump or a ventricular assist device may be employed if the patient experiences cardiac failure or an inability to wean from CPB. Dysrhythmias may also be a common complication during this process and can be treated either through pharmacologic or electrical therapy, such as defibrillation or synchronized electrical cardioversion, depending on the patient's cardiac rhythm and hemodynamic status.

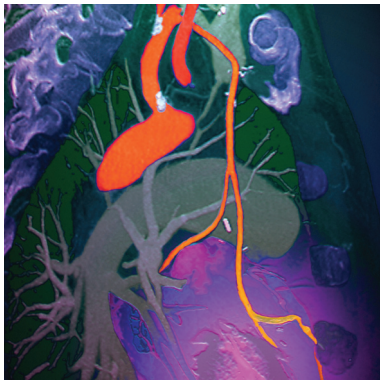
Investigators have examined CABG's effect on the coagulation and complement cascades, which are affected when the patient's blood comes into contact with the extracorporeal circuit of CPB.[5] Common hematologic complications after bypass include hemodilution, hemolysis, and decreased coagulation factors, which result

in the necessity for blood transfusion. Patients with longer CPB runs can experience more deleterious effects including compromise of the immune system, which may lead to multisystem organ failure.

Pulmonary complications of CPB result from hypoventilation, accumulation of extravascular fluid, and decreased surfactant, which contributes to atelectasis. Postoperative respiratory complications can range from atelectasis and pneumonia to acute respiratory failure.

A major complication post-CPB is acute renal failure (ARF), which occurs in 7% to 8% of patients.[4] Older adult patients are most likely to experience ARF, especially if they have low cardiac output, oliguria, or renal dysfunction preoperatively. Patients with borderline renal function prior to surgery may require short-term dialysis postoperatively until renal function is restored.

Short-term neurologic changes include memory loss, difficulty thinking clearly, and problems concentrating for lengthy periods of time. Recent research has raised the question of whether these short-term changes may affect long-term cognitive function.[6] The reason for cognitive deficits isn't definitely known, but may be related to microemboli released from atherosclerotic plaque or blood transfusions. It's also been attributed to the CPB machine and its effects. The emboli may affect the brain, resulting in cognitive dysfunction.[6] Other neurologic complications that may occur range from swallowing deficits to global stroke and death, which has an occurrence rate of approximately 8%.[7]



CABG decreases the overall mortality of coronary heart disease, improves the functional status of patients, and provides relief from angina.

Despite these complications, upwards of 50% of CABG procedures performed at most of the 900 cardiac surgery centers in the United States use CPB.

Many surgeons choose this traditional technique because of the intense debate as to completeness of revascularization with minimally invasive surgeries. The decision to perform a procedure on or off CPB is often made during the procedure itself as the surgeon evaluates the patient's progress and adequacy of perfusion.

Intraoperative phase

Nursing care during the intraoperative phase of cardiac surgery focuses extensively on the perioperative nurse acting as a patient advocate during a time when the patient is most vulnerable. Patient safety issues that create and maintain safe-care environments are the perioperative nurse's immediate responsibility, and may include activities such as correct patient identification for the surgical procedure and medication administration, preparation of specimens, and blood transfusions. Continuous monitoring of the patient during the procedure is the surgical team's responsibility, with the perioperative nurse assuming responsibility for many aspects of care. The proper positioning of the patient to prevent injuries, communication of information to the members of the healthcare team, and the documentation of care, medications, and treatments must be completed. Providing emotional support to the family, depending on the hospital's protocol for family updates, keeps family members informed as to the patient's condition and the progress of the surgical procedure. Emergencies that arise in the OR, such as cardiac arrest during induction or failure to come off bypass, are complications that require extraordinary rapid sequence activities that become routine for most programs as they develop expertise with cardiac surgery emergencies.

Much like the preoperative phase, the intraoperative phase is an anxiety-producing situation for family members. Research suggests that intraoperative progress reports are beneficial to assisting the family in controlling their anxiety and increasing family members' sense of control.[8] Decreasing the stress associated with the intraoperative period can positively affect the family's ability to respond to education, and may also significantly impact patient outcomes. Communication may occur in the form of telephone updates or in-person reports following a standard protocol.

Surgical approaches

The first efforts to alter the surgical approach from median sternotomy to smaller, less traumatic incisions began in the mid-1990s. Starting with initial attempts at CABG surgery through limited access with and without robotics, a number of cardiac procedures were developed and are currently being performed by minimally invasive approaches. These techniques not only alter the surgical approach, but whether the patient is placed on or off CPB. Off-pump coronary artery bypass (OPCAB), robotic-assisted coronary artery bypass (RACAB), and totally endoscopic coronary artery bypass (TECAB) using Heartport are some of the minimally invasive approaches currently available. In addition to CABG, minimally invasive approaches may be used with mitral valve repair, transapical aortic valve implantation, endoscopic pulmonary vein isolation for the treatment of atrial fibrillation, and the treatment of aortic aneurysmal disease by thoracic endografting.

OPCAB offers certain advantages in low-risk patient populations, such as decreased cost; reduced length of stay; reduced postoperative complications, such as psychomotor and cognitive deficits; and avoidance of blood transfusions. It also reduces surgical trauma to the patient, as well as stroke and kidney failure. In older adult, high-risk patients, minimally invasive cardiac surgery may reduce the risk of stroke, renal failure, prolonged respiratory assistance, and, perhaps death.[4]

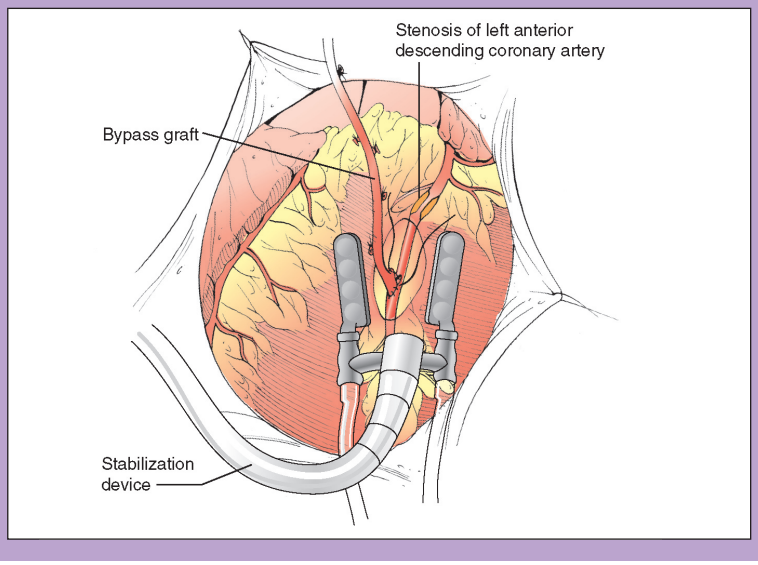
While select research demonstrates reduced risks from minimally invasive procedures, most studies show complications involving the renal, neurologic, hematologic, and cardiac systems, which are similarly experienced in traditional CABG surgery.[5] An additional complication may be the inability to completely revascularize the heart, leaving significant lesions untreated due to their location. Conversion to a full sternotomy or CPB is expected in approximately 1% to 2% of patients. Other patients experience complications involving rib fractures at a rate of 10%.[5]

Minimally invasive direct CABG procedures may be limited to a set of patients requiring only one to two bypasses in one or two coronary arteries located on the anterior surface of the heart. Often the patient is considered too high of a risk for traditional bypass surgery. Although minimally invasive procedures are usually associated with low mortality, patients may experience a myriad of postoperative complications.

Despite the differences in patient selection and treatment strategy, research doesn't demonstrate any significant survival advantage for patients having OPCAB in comparison with conventional CABG. However, one of the primary goals of OPCAB is to decrease the morbidity of CABG by less invasive and traumatic techniques. OPCAB surgery differs from traditional coronary artery bypass surgery because the CPB system isn't used. Because of this, the heart isn't arrested with cardioplegia, but is held in place by mechanical stabilizers and positioning devices during the procedure. (See *Stabilizer device for off-pump coronary artery bypass surgery.*)

An apical suction device is placed on the apex of the left ventricle to manipulate the heart and expose the different coronary arteries. The surgeon bypasses the targeted coronary artery while the rest of the heart keeps pumping and circulating

Stabilizer device for off-pump coronary artery bypass surgery

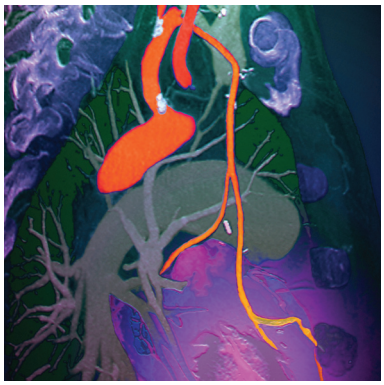


blood to the rest of the body. In general, the types of patients with coronary artery disease who are candidates for OPCAB include those with very low ejection fractions, severe lung disease, acute or chronic kidney failure, high risk for stroke, and calcified aorta.[5] Conversion to CPB may be required if the patient can't be revascularized due to hemodynamic instability, refractory dysrhythmias, significant ischemia, poor anastomosis, or poor surgical site access.

Technological advances

Advances in video imaging, endoscope technology, and instrumentation have made it possible to convert some surgical procedures from open surgeries to endoscopic ones. For example, CABG surgery is achievable using a computerized robotics team. Through one port, a tiny, high-powered, voice-operated camera or endoscope is inserted and stabilized with a robotic arm. Two robotic arms control the surgical equipment that's inserted in the other ports. The surgeon makes a small incision into the chest and then operates the robotic arms to perform the procedure. Advantages for this type of procedure are the minimal incisions, the absence of a CPB system, and the precise movements that are beyond the ability of the human eye.

Surgeons were once wary of the time and training that robotics required.[9] Future research will focus on delivery of diagnostic and therapeutic modalities under remote control and navigation that could make noninvasive surgery a reality. One drawback, however, is that RACAB still isn't readily available at most cardiac surgery centers.



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TECAB surgery using port access

Port-access cardiac surgery (PACS), begun in 1995, has a learning curve that's a challenge for the skilled and experienced cardiac surgeon. This type of minimally invasive surgery isn't only technically difficult, but requires specialized expertise from anesthesiologists and surgeons and increases OR utilization. Anesthesiologists must be proficient in transesophageal echocardiography to guide proper placement of the coronary sinus catheter, pulmonary artery catheter, venous drainage cannula, and endoaortic balloon catheter. The proposed advantages of PACS include less postoperative pain, decreased hospitalization and rehabilitation periods, and reduced healthcare costs, which remain unsubstantiated by properly designed prospective investigational research studies. PACS is associated with unique challenges and potentially lethal risks, such as aortic dissection, aortic valve trauma, coronary sinus trauma, and right ventricular rupture.[10] These risks aren't commonly associated with conventional cardiac surgery. Proper placement of a double-lumen endotracheal tube with one-lung ventilation is required. An anterior mediastinotomy and thoracic port in conjunction with a specially designed set of endovascular catheters is also used. These catheters, and the use of a modified CPB system, provide complete cardiopulmonary support. Surgeons must operate through small incisions, and the quality of the surgical results may be suboptimal. The benefits of TECAB include reduction of surgical trauma, smaller surgical incision, and in some cases the elimination of CPB. The survival rate is reported in some articles as 99%, with an incidence of perioperative stroke of 1% and an aortic dissection rate of 1%.[10] Other complications are noted to be similar to comparable minimally invasive techniques.

Postoperative phase

The perioperative nurse's role is often complete once the patient is transferred to the critical care recovery unit. The handoff procedure, a current Joint Commission focus, allows for continuity of care for the patient and his or her family, and is established by hospital protocol. In some institutions, the perioperative nurse may complete a follow-up visit to assess the patient and family's

satisfaction with the operative experience. This is often done on the second or third day postoperatively, and may follow a standard protocol.

The National Heart, Lung, and Blood Institute Working Group has determined that future directions in cardiac surgery must support a large, multicenter, randomized, clinical trial to compare OPCAB surgery with traditional surgery. Research emphasis should also focus on computer-enhanced imaging, instrumentation, and robotics. Some of the barriers to clinical research must be addressed so that patients receive the highest quality of care that can be provided.

More than 910,000 Americans die of heart disease each year in the United States. Approximately 70 million Americans live every day with some form of cardiac disease.[11] One thing is certain: These patients are seeking less invasive surgeries with a short recovery time that allows them to quickly resume their lives. The future holds many exciting possibilities in the field of minimally invasive cardiac surgery. ❖

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Victoria A. Kark is an open heart clinical specialist at Suburban Hospital, Bethesda, Md. She is also an adjunct faculty member at Columbia Union College, Takoma Park, Md.

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