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Minimally invasive cardiac surgery: new challenges for the surgeon and the anesthesiologist

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Despite major changes in the demographic profile of the surgical population with an increase in the proportion of older patients undergoing cardiac surgery presenting multiple risk factors, the perioperative mortality and morbidity have declined significantly. These improvements are attributed in part to better management of anesthesia and newer surgical techniques. Conventional open-heart surgery is associated with considerable physiological and psychological adverse effects as a result of the general anesthesia, midline sternotomy, and the use of cardiopulmonary bypass. In recent years, cardiac surgery has advanced by leaps and bounds, most notably by the development of less invasive surgery including minimally invasive direct coronary artery bypass, off-pump surgery, and totally endoscopic with or without robotic assistance. Minimally invasive cardiac surgery has been proposed to reduce surgical trauma, decrease morbidity, lower the procedural costs, and increase patient satisfaction. Patients undergoing minimally invasive surgery have less pain, require less use of blood products, leave the hospital sooner, and return to preoperative functional levels sooner. However, minimally invasive cardiac surgery presents more technical difficulties, a learning curve, and is accompanied by significant surgical hurdles. Along with the development of new surgical techniques and skills, the cardiac anesthesiologist is undoubtedly facing new challenges. Minimally invasive surgery requires a carefully orchestrated coordination of efforts between the surgeon, perfusionist, and anesthesiologist.

Coronary artery bypass grafting (CABG) is one of the most frequently performed surgical procedures in Canada and the United States.[1] This procedure is safe and remains the most effective treatment available for severe coronary heart disease. Over the last decades, despite major changes in the surgical population with a dramatic increase in the risk factor profile and percentage of older patients undergoing cardiac surgery, operative mortality and morbidity have declined significantly.[2] These improvements may be attributed to better management of anesthesia and surgical techniques, along with improved strategies for myocardial protection.[3]

Conventional heart surgery requires general anesthesia and median sternotomy to expose the heart and its vessels. Until recently, cardiopulmonary bypass (CPB; also termed heart and lung machine) was virtually always used to ensure systemic perfusion and to arrest the heart, while providing

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an optimal operating field ("on-pump CABG").[3] However, CPB is associated with numerous adverse outcomes that are primarily related to manipulation and cannulation of the ascending aorta, the initiation of a systemic inflammatory response, and microembolization.[4,5] Less invasive surgery without bypassing the lungs and heart may be of particular benefit, mainly in high-risk patients, to avoid many of the complications related to the use of CPB. Off-pump coronary artery bypass grafting (OP-CABG) has been proposed as an approach to decrease neurological injury, blood products requirement, renal dysfunction, overall morbidity, resource use, and costs. Two decades ago, the success of laparoscopic cholecystectomy with its clear benefits compared with traditional open surgery reawakened the interest of cardiac surgeons and of their patients for minimally invasive approaches in heart surgery.[6]

Need for minimally invasive surgery

Coronary artery bypass grafting surgery (CABG) remains the gold standard for coronary revascularization, but it does present a number of procedural shortcomings. The pitfalls of CABG include the need for sternotomy with its risk of dehiscence, prolonged discomfort, chronic pain, infection (particularly for diabetic patients in whom bilateral internal thoracic arteries are used); aortic manipulations with the risk of cerebrovascular accident and aortic dissection; the use of CPB with the activation of the coagulation and complement cascade resulting in coagulopathy, inflammation, and organ dysfunction; and the use of vein grafts with their limited long-term patency rate.[7,8]

In recent years, CABG surgery has advanced by leaps and bounds, most notably by the development of minimally invasive direct coronary artery bypass (MIDCAB), OP-CABG, and totally endoscopic with or without robot-assisted CABG (TECAB).[9] The definition of minimally invasive cardiac surgery is broad, but it involves at least one of the following: modification in standard incisions, operation through a smaller incision, surgery without stopping the heart or by avoiding the use of CPB. It can be applied during CABG as well as during valvular and other intracardiac operations.

Unlike coronary artery surgery where the term "minimally invasive" often refers to the avoidance of CPB or OP-CABG, heart valve surgery is presently dependent on the use of extracorporeal circulation.[10] Traditionally, open-heart surgery for valve replacement or repair involved considerable physiological and psychological adverse effects as a result of the midline sternotomy, CPB, and cardioplegic arrest.[6] The main goals of minimally invasive surgery are to reduce surgical trauma, increase patient satisfaction, reduce morbidity, and lower procedural costs while providing safe and durable surgical treatment.[6,10] However, minimally invasive cardiac surgery presents more technical difficulties, a learning curve for the surgeons and their collaborators, and is accompanied by significant surgical hurdles. These advantages and disadvantages are outlined in Table 1.

Table 1 Advantages and disadvantages of minimally invasive surgery

Advantages	Disadvantages
Reduced pain	Learning curve
Smaller incisions and scars	Longer operating room and CPB times
Less bleeding and need for blood product	Require complex and costly equipments
Fewer complication: stroke, MI	Not suitable for all patients
Shorter hospitalization	Reduced cardiac exposure and safety?
Faster recovery	Unknown long-term benefits?
Greater patient satisfaction	Increased costs?
Improved hospital resources utilization	
Better visualization of intracardiac structures	

New challenges for the anesthesiologists

Along with the development of new surgical techniques and skills, the cardiac anesthesiologist is undoubtedly facing new challenges. Proper preparation and positioning of the patient are crucial. Surgeons and anesthesiologists are working together to improve exposure and enable the performance of complex procedures. Multiple central venous catheters and bilateral arterial lines are often required, and external defibrillator pads are installed before positioning the patient. Also, with anterior thoracotomy instead of midline sternotomy, double-lumen intubation guided by bronchoscopy with selective one lung ventilation is required; catheters and cannulas are positioned by transesophageal echocardiographic (TEE) guidance into the coronary sinus and pulmonary artery.

The preferred anesthetic technique used for heart surgery still consist of general anesthesia (GA). Procedures to reduce perioperative mortality and morbidity during open-heart surgery have constantly evolved, and new strategies in cardiac anesthesia now enable ultra-fast-track (UFT) and immediate extubation.[11-13] The use of high thoracic epidural anesthesia (TEA) is a useful adjunctive anesthesia and analgesia to conventional GA techniques, and has been shown to be beneficial in patients with coronary artery disease.[14] In addition to numerous intraoperative advantages, the benefits of TEA can persist in the postoperative period, improving recovery and early mobilization. An additional approach to decrease general trauma is the avoidance of GA. An immense step forward in cardiac anesthesia was first described by Karagos and coworkers in 2000 in which CABG was performed in an awake patient without endotracheal intubation and GA (conscious coronary artery