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ROBOTIC SURGERY AND ANAESTHESIA

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The ultimate goal of minimally invasive coronary artery bypass grafting is to perform the anastamosis entirely endoscopically. Significant technological advances have enabled the development of minimally invasive endoscopic operative techniques in a variety of disciplines. These procedures are ultimately aimed at reducing patient morbidity, length of hospital stay, and overall costs.

The surgical telemanipulation system, derived from space and military technology, provides surgeons with the tools to perform totally endoscopic coronary anastomosis by allowing several degrees of freedom of motion.

Robots in Cardiac Surgery

The first group of robots consisted of assisting tool that are used for holding and positioning the endoscope during surgery. The robot AESOP (Automatic Endoscopic System for Optimal Positioning: Computer Motion Inc, Goleta, CA) can be used for various surgical procedures to guide the endoscope using voice control.

The second group of robots comprises telemanipulators that were originally invented to facilitate working under remote or hazardous conditions, such as nuclear plants.1 Telemanipulators are under the constant control of an operator who works at a console using commands or motions to direct the manipulators. The operator (surgeons) and the manipulator (robot) can be connected mechanically or electronically by a controller panel. Tremor filtering and motion scaling support dexterous manipulations in confined spaces by ports or trocars. Two telemanipulation systems that are currently in use for cardiac surgery are the da Vinci Robotic System (Intuitive Surgical Inc, Mountain View, CA) (Fig.1) and the ZEUS Robotic System (Computer Motion Inc, Goleta, CA).

The advantage of the da Vinci system include integrated three-dimensional visualization and a robotic wrist at the end of the instruments that provide articulated motions with 7° of freedom (DOF) of movement inside the chest cavity. The ZEUS system lacks an articulated wrist allowing only 4-5 DOF inside the chest cavity.2

In 1998, Carpentier et al3 and Falk et al4 independently reported the first mitral valve repair using the da Vinci robotic system through a 4-7 cm minithoracotomy using separate ports for surgical instrumentation.

Laborde et al2 published the first series of total endoscopic patent ductus arteriosus (PDA) closure using the ZEUS robotic system achieving not only better cosmetic results, but also reducing pain in the postoperative period. Dogan et al5 were the first to report a successful case of totally endoscopic ASD closure using the da Vinci system.

The da Vinci telemanipulation system is used in our institute. It consists of a master console (Fig.2) for remote control of the microinstruments on a slave unit, that is a surgical cart with three arms. The middle arm carries a stereo endoscope, and the left and right arm serve as endothoracic end effectors for remote tissue manipulation using microinstruments resembling the human wrist. An additional video cart carries the light source, a carbon dioxide insufflator, an image processor, and a conventional 2-dimensional screen. A surgical assistant places the ports. The surgeon is seated at the master console and controls the endoscopic instruments, as well as the camera mounted on the slave unit (Fig. 3). The image from the stereo endoscope is transferred to the master console, magnified (10 x) and projected as a 3-dimensional image for optimal visualization of the surgical field. 6

Endoscopic Coronary Artery Bypass Graft

Both Internal mammary arteries (IMA) can be approached from both the left and the right hemithoraces. In a typical left-sided approach for left anterior descending coronary artery (LAD) bypass, the patient is placed on the operating table in a supine position with the left side of the chest elevated about 30° to 40°. The thoracic landmarks such as jugulum, xiphoid, and ribs are marked for external orientation and port placement. After deflation of the left lung, the camera port is placed bluntly to avoid left ventricular injury. Usually the fifth intercostal space close to the anterior axillary line is identified and the chest is insufflated with warm carbon dioxide (37° C). After insertion of the endoscope, two ports are placed under visual control to accommodate the two robot arms, usually in the third and seventh intercostal spaces. The left IMA is mobilized from the subclavian artery all the way down to the distal bifurcation with a 30° endoscope angled upward. Most side branches of the IMA are cauterized by means of low energy cautery.

The left femoral artery and vein may be dissected for instituting femoro-femoral bypass with the use of the post access system6. In our institute, off pump totally endoscopic CABG (TECABG) is performed using a da Vinci system for a single vessel graft only.

Anaesthesia for off pump TECABG

In our institute, off pump TECABG is performed for a single vessel graft only. Patients are premedicated with Inj Morphine 0.1mg/kg body weight and Inj Glycopyrrolate 0.01mg/kg body weight intramuscular injections 45 minutes before surgery. All cardiac medications are continued upto the day of surgery. Patient monitoring consists of standard ECG leads II and modified chest lead, arterial BP (femoral artery) and pulmonary artery pressures and cardiac output by a pulmonary artery catheter through 8.5F introducer sheath into the right internal jugular vein. Induction of anaesthesia is achieved with titrated doses of midazolam, fentanyl, thiopentone and non depolarising muscle relaxant (Vecuronium, Pancuronium). Left sided double lumen Robert Shaw endobronchial tube is used for intubation and the position is ascertained by a Fiberoptic Bronchoscope. A multiplane transesophageal echocardiography probe is placed in all patients after intubation.

External defibrillation patches are applied in all cases. Patients are placed in the supine position with the left arm above the head and a slight lateral tilt by rotating the table 30° towards the right and elevation of the left hemithorax. Anaesthesia is maintained with Isoflurane in oxygen and intermittent bolus doses of muscle relaxant, fentanyl and midazolam. All patients are prepared and draped as for conventional cardiac surgery, permitting sternotomy in case of need. Single lung ventilation is started and port placement takes place. Carbon dioxide is insufflated into the left pleural space so as to obtain an intrapleural pressure of 5-10mmHg and to allow exploration of the pleural cavity with an endoscope. Haemodynamic disturbances due to intrathoracic pressure7 are counteracted by I/V fluids and inotropes / vasoconstrictors. Patients are ventilated with 100% oxygen. Oxygen saturation and end tidal carbon dioxide are displayed continually by pulse oxymetry and capnography with ventilation adjustment required to ensure a partial pressure of 35-45mmHg. If hypoxia occurs then 10 cm PEEP is appled to the ventilated lung and 5-10 cm CPAP sometimes is applied to the non ventilated lung. Bispectral index monitoring is done in all pat ients to ensure an adequate anaesthetic depth.

Surgical and total operation theatre time is long so hypothermia is an important issue and active warming procedures are undertaken. Anaesthetic tubes need to be a bit longer in order to have the anaesthesia machine and monitor to be a little away from the patient in order to reduce the cluttering and prevent interference with movements of the robotic arms.

On completion of anastomosis, both lungs are ventilated and reintubation is done with a single lumen endotracheal tube at the end of surgery.

For procedures performed with Port-Access technology, endoarterial return cannula and endovenous drainage cannula (Heartport, Inc, Redwood City, CA) are introduced through the femoral vessels. The endoaortic clamp catheter is positioned in the ascending aorta with the aid of TEE. The surgical arms are repositioned through the ports into the thoracic cavity. CPB is established, ventilation stopped and the pericardium is opened with the use of a three dimensional rigid endoscope, cautery and a grasper. After localization of LAD artery, the endoaortic clamp is inflated to a pressure of 350mmHg and cold blood cardioplegia is delivered. When myocardial protection is ensured, the LAD artery is dissected and opened with the use of telemanipulated robotic instruments.

On completion of anastamosis, both lungs are ventilated and the patient is rewarmed to 36.5°C and weaned off CPB8.

The first and second port orifices are closed and a chest tube is placed through the third port. Patient is shifted to recovery unit. On ensuring hemodynamic stability, rewarming and minimal blood loss, weaning from the ventilatory support is started.

Conclusion

The early results with robotic systems in cardiac surgery suggest that completely endoscopic approach to different cardiac operations are feasible. However, the anaesthesiologist is also confronted with a multitude of situations requiring multiple management skills.

The anaesthesiologist should be versed in cardiac and thoracic anaesthesia and must possess the skills required for TEE and nonsternotomy CPB.

Figure 1. DaVinci Tele manipulation system- Master console and Surgical Cart

Figure 2. Surgeon on Master Console

Figure 3. Robotic surgery in progress

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