Minimally invasive cardiac surgery—from early steps to consolidation

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In this special issue of the *Indian Journal of Thoracic and Cardiovascular Surgery*, we have the great pleasure of presenting work of respected surgeons and interventional cardiologists who give an overview on current developments in less traumatic approaches to heart surgery. The articles walk the reader through the spectrum of cardiac disease in the adult and include coronary bypass surgery, valve surgery as well as implantation of left ventricular assist devices (LVAD).

Minimally invasive cardiac surgery (MICS) looks back into 20 years of development starting from increased efforts to perform coronary bypass grafting on the beating heart to development of small access surgeries on both the coronary arteries and the heart valves and to application of advanced techniques which include videoscopes, robotic technology, and refined catheter-based interventions.

Minimally invasive coronary bypass surgery

Coronary artery bypass grafting can to date be performed through mini-incisions on the beating heart. This so called minimally invasive cardiac surgery (MICS)—coronary artery bypass grafting (CABG) has become routine at several centers and series of hundreds of patients are published. Marc Ruel's group from the Ottawa Heart Center in Canada describes the current state of the art and technical details on how to perform the procedure. Robert Poston's group from St. Francis Hospital at Trenton, New Jersey, USA, outlines the technique of robotically assisted CABG through minithoracotomy and gives valuable recommendations for program development. Poston highlights the importance of team work and effective team leadership. In his opinion, the main hurdles to successful introduction of robotic CABG are limited access of the main

surgeon to the patient, limited access to the heart if the operation is performed through a minithoracotomy, prolonged CO₂ insufflation in the totally endoscopic version of the procedure, and difficulties in rapid cannulation and defibrillation when the procedure is performed on the beating heart. He also points out the importance of adequate training schemes and proper patient selection. Laszlo Gobolos from the team at the Cleveland Clinic Abu Dhabi describes developments in robotic totally endoscopic coronary artery bypass grafting (TECAB); Mahmoud Traina from the same group presents the principles of hybrid coronary revascularization which combines TECAB and percutaneous coronary intervention in order to get the best out of surgical and catheter-based interventional methods for the benefit of patients. Both articles demonstrate that TECAB has developed from single left internal mammary artery (LIMA) to left anterior descending artery (LAD) bypass grafting to multivessel surgical endoscopic revascularization. Combining the procedure with percutaneous techniques allows minimally invasive treatment of multiple coronary artery lesions.

Minimally invasive heart valve surgery

Machiraju et al. from Philadelphia present a bird's eye view of various approaches to mitral valve surgery including their pros and cons. Less invasive valve surgery is probably the most accepted version of MICS. In the late 1990s, mitral valve repair through small incisions on the right chest with fem-fem access for the heart lung machine and transthoracic aortic cross clamping or use of the endoballoon for endoaortic clamping for cardioplegia became popular. Incision length has decreased significantly and more and more complex repairs are carried out. Latest developments include 3D videoscopes which significantly enhances vision and work comfort during the procedure. Manuel Wilbring from Hendrik Treede's group at the Martin Luther University in Halle, Germany, reports on their experience. He points out that minimally invasive mitral valve surgery additionally provides reduced morbidity by means of bleeding, transfusions, re-exploration, and impaired wound healing. Reduced

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postoperative pain is a major benefit of minimally invasive mitral valve surgery. This beneficial effect additionally can be enhanced by implementation of a non-rib-spreading, fully-endoscopic approach. The reduction of postoperative pain translates into improved patient satisfaction, shorter length of stay, and lower health care expenditures. Hoda Javadikasgari and Stephanie Mick from the Cleveland Clinic Main Campus in their paper outline the advantages of robotic technology in minimally invasive mitral valve repair. Indications and contraindications are listed and the surgical technique is described in detail. Dr. Alla and colleagues from Hyderabad, India, present their experience of mitral valve surgery through right antero-lateral thoracotomy along with a brief review of existing literature.

Catheter-based techniques for mitral valve repair and replacements are probably the most active field of current research. Anson Cheung from the University of British Columbia in Vancouver, Canada, current President of the International Society for Minimally Invasive Cardiothoracic Surgery, presents an overview of techniques and implant devices. As the indications at present mainly include the difficult group of patients with functional mitral valve regurgitation, outcomes remain challenging. The latest device which shows traction in catheter-based mitral valve repair is the Cardioband™. This band is implanted through transfemoral venous and transseptal approach under 3D TEE guidance. Adolfo Ferrero Guadagnoli from Francesco Maisano's group at the University of Zurich, Switzerland, in their contribution to our special issue write about the implant technique and results of early clinical trials. They also describe the use of the Cardioband™ in tricuspid valve repair. Alternative technologies are also described.

Sathyaki Purushotham Nambala and his team from Apollo Hospitals, Bangalore, India, in their article ask the provocative question if minimally invasive aortic valve replacement (mini AVR) is worth the effort. The various limited incisions to access the aortic valve are described, and cannulation techniques are presented. Results in the literature are reviewed and the scarcity of proper randomized comparative trials is highlighted. A very detailed analysis of available randomized and non-randomized studies is provided. Antonio Lio and Mattia Glauber from the Istituto Clinico Sant Ambrogio – Gruppo Ospedaliero San Donato, Milan, Italy, give an overview what sutureless aortic valve prostheses can offer for the minimally invasive cardiac surgeon. Studies have consistently shown faster implantation of valve substitutes which is specifically interesting for surgeons working through limited incisions. The most dramatic developments in treatment of aortic valve stenosis are seen in transcatheter aortic valve replacement (TAVR). Well-developed prospective randomized trials have demonstrated clear advantages over surgical aortic valve replacement in high-risk patients. Value is also seen in patients

with intermediate surgical risk. Ahmad Edris from the Heart and Vascular Institute at Cleveland Clinic Abu Dhabi describes the technique and post interventional care and provides arguments for using catheter-based or surgical approaches in different subgroups of patients. He highlights the importance of a heart team approach to performing TAVR. It appears to be clear that TAVR will be moving from application in high-risk patients to routine implantation in patients with intermediate risk.

Minimally invasive LVAD implantation

Over the last years, techniques have been developed which allow implantation of ventricular assist devices through thoracic mini-incisions. Some procedures are carried out even without use of the heart lung machine. As described by Dominik Wiedemann and Thomas Haberl from the Medical University of Vienna, Austria, this recently introduced method is still controversial but positive effects in reduction of morbidity are visible. Bleeding can be significantly reduced, there appears to be less inotropic support postoperatively, and the right heart is better protected. The sub-pericardial placement of the outflow grafts provides significant advantages during re-entry for heart transplantation. There are data to show that even mortality could be reduced.

Bottom line

Minimally invasive heart surgery has developed after the successes of less invasive and endoscopic approaches in general surgery, urology, gynecology, and orthopedics. Given the dramatic consequences of failure in cardiac procedures, development was relatively slow but constant. Many procedures have become routine at dedicated centers, a wealth of publications is available in the literature, specific societies for less invasive heart surgery exist, and major existing societies have formed working groups for the field. From our special issue, it is also apparent that less invasive heart surgery can only be further developed in strong interdisciplinary cooperation with our colleagues in cardiac imaging and interventional cardiology. Minimally invasive cardiac surgery will flourish in heart team environments and research will be productive in such teams. It will be successful if surgeons embrace new technologies in imaging, videoscapy, and catheter-based interventions. The future of the subspecialty is bright and I encourage both young surgical researchers as well as experienced surgeons to invest in the topic and to dedicate their work to advancing the field of MICS.