

The Development of Slovenian Heart Surgery: Celebrating 50 Years (1958–2008)

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ABSTRACT

Background: The beginnings of Slovenian cardiac surgery reach back to 1958, when the first heart surgery using extracorporeal circulation (ECC) was performed. The 50th anniversary of this event was the impetus for reviewing its developmental path.

Methods: History of medicine methodology, including analysis of archival materials, documents, and various publications of the Department of Cardiovascular Surgery, Ljubljana University Medical Center, Slovenia.

Results: Presentation of the development of Slovenian cardiac surgery from 1958 to 2008.

Conclusion: Small countries may not be able to contribute great developmental steps to world cardiac surgery, but the work of individuals from these countries can represent a contribution to the development of the discipline.

INTRODUCTION

In 2008, Slovenian cardiac surgery celebrated its 50th anniversary. After the first successful cardiopulmonary bypass surgery performed on 23 September 1958 using a Slovenian-made cardiopulmonary bypass machine similar to that designed by Clarence W. Lillehei, Slovenian cardiac surgery saw relatively rapid development. A key factor in this was the commitment of the medical staff of that time, despite scant material resources and an acute shortage of professional staff.

Small countries usually do not have the means to contribute to the global development of high-tech disciplines. This is especially true in cardiac surgery, which is highly subspecialized and is connected with expensive equipment and heavy investment in research, development, and training. The cardiac surgery of small nations, such as Slovenia with its population of 2 million, is primarily important for treating cardiac surgical patients at the local level. In order to spread knowledge and introduce new methods, local cardiac surgeons form connections with the discipline around the world. This discipline usually operates in a similar fashion in all small countries around the world.

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MATERIALS AND METHODS

At the Ljubljana University Medical Center, the Department of Cardiovascular Surgery keeps an archive of its 50-year-long operation, which has not yet been processed from the viewpoint of the history of medicine, development, and the profession. On this anniversary, the publications by its professionals to date were also reviewed.

RESULTS

The beginning of Slovenian cardiac surgery in the mid-twentieth century was only possible with sufficient professional capacity of the Ljubljana Clinical Hospital, which provided the surgeons preoperative support through cardiology, pediatric cardiology, and radiology diagnostics, intraoperative support through anesthesiology management, and postoperative support through intensive and nursing care. Slovenian cardiac surgery was pioneering even within Yugoslavia with its population of 20 million, which Slovenia was part of until 1991, when Yugoslavia collapsed and Slovenia declared independence (Figure 1).

Slovenian cardiac surgery developed from general surgery headed by Božidar Lavrič (1899–1961), within which vascular surgery, especially procedures on the great vessels, were also performed [Lavrič 1958]. In 1961, an independent department of cardiovascular surgery was established. Its management was assumed by Miro Košak (1919–), who headed it until 1987 [Šušteršič 1991] (Figure 2). Slovenian cardiac surgery began developing even before the introduction of extracorporeal circulation (ECC). In 1952, Slovenian surgeon Boris Kunc (1909–1992) performed the first commissurotomy for mitral stenosis in Yugoslavia [Šušteršič 1992]. The founder of cardiovascular surgery in Slovenia and the former Yugoslavia was Miro Košak. In 1947, he introduced endotracheal anesthesia in Ljubljana. Košak helped create and promote teamwork in cardiovascular surgery, accelerated the development of the clinical laboratory, the tissue-typing laboratory, transfusion, and the invasive diagnostics x-ray department, and laid the foundations for today's intensive care and nursing.

It is interesting to note how long it took for new surgical techniques in cardiac surgery to be introduced to Slovenia from abroad. In 1953, the American surgeon John Gibbon and his colleagues introduced cardiopulmonary bypass, which enabled the performance of open-heart surgeries using hypothermia. In Ljubljana, a Slovenian-made cardiopulmonary



Figure 1. Map of Slovenia and Europe.

bypass machine was introduced into clinical practice in 1958 after performing 24 experimental ECC surgeries with this machine on dogs within a year. After this, the Slovenian-made machine was used in 3 more heart surgeries, and from July 1960 onwards an original US-manufactured Lillehei-DeWall device was used [Kořak 1959].

This was followed by additional cardiac surgical procedures: in 1965, Miro Kořak and his colleagues (Duřan Muller, Jolanda Jezernik, Marjan Gros, and Anton Jagodic) were the first in Yugoslavia to implant a Starr-Edwards ball valve and a pacemaker. In the following 40 years (1965–2005), around 5000 pacemakers were implanted. To contextualize this, the Swedish surgeon Åke Senning implanted the first pacemaker in 1958, and Albert Starr implanted the first ball valve in 1960. Later on, artificial valves produced by other manufacturers and of various shapes, such as those with movable discs and carbon leaflets (McGovern, Sorin, Carbomedix, St. Jude, and others) were used. In 1984, Borut Pirc and his colleagues started performing modern reconstruction procedures on heart valves. Since 1997 (under Borut Gerřak), an increasing number of biological valves have been used in older patients due to their better hemodynamic properties and the fact that the patients do not require anticoagulant treatment. In 1980, Michel Mirowski installed the first implantable defibrillator. In 1989, the first automatic implantable cardioverter-defibrillator (AICD) was implanted in Ljubljana (by Aleř Breclj). At that time, the device had to be installed via thoracotomy and by sewing electrodes to the epicardium. Later on, a subxyphoid approach began to be used, and today's development of devices (ie, using a biphasic shock waveform, designing intracavitary electrodes with larger surface areas, and utilizing the device's housing as an electrode) allows for endocardial implantation of defibrillation systems.

In surgical treatment of ischemic heart disease, the Ljubljana surgeons followed the examples around the world and initially performed indirect cardiac revascularization procedures; in 1971, they performed the first successful direct revascularization using an aortocoronary-vein bypass (by Kořak).



Figure 2. The founding father of Slovenian cardiac surgery, Miro Kořak (1919–), was among the first in the world to perform a successful cardiac autotransplantation.

Two years later (in 1973), the mammary artery was used for the first time to bypass the coronary artery [Gabrijelčič 1993]. To compare this with international achievements, the first aortocoronary artery bypass surgery was performed in 1964 by Edward Garrett [Kirklin 1986], and the father of coronary surgery is considered to be the Argentinean surgeon René Favaloro, who was the first to bypass a narrowed part of a coronary artery with a substitute vein in 1967. With the introduction of cardioplegia in 1975 (by Jolanda Jezernik), complex heart surgeries also began to be performed.

In the 1960s and 70s, Slovenian cardiac surgeons underwent training at various European cardiac surgery centers, such as the Cardiology Hospital in Lyon, the Broussais Hospital in Paris, the Copenhagen University Hospital (Slovenian anesthesiologists also trained in this city through the financial support of the World Health Organization), Surgical Clinic A at the University Hospital in Zurich, the Hammersmith Hospital, Brompton Hospital, and the National Heart Hospital in London, and elsewhere. Later on, they trained more frequently in the US: at the Texas Heart Institute in Houston, TX; the Cleveland Clinic Foundation and the Department of Thoracic and Cardiovascular Surgery in Cleveland, OH; the Oxford Heart Centre, Children's Hospital, and the Women's Hospital in Boston, MA; and the Providence Heart and Vascular Institute at the University of Oregon in Portland, OR. This cooperation also resulted in various internationally



Figure 3. Michael DeBakey and his colleagues visiting Ljubljana in 1967.

renowned heart surgeons visiting Ljubljana. Among these, the most significant was certainly Michael DeBakey, who visited Ljubljana in 1967 together with his team of 10 associates and complete cardiac surgical equipment (Figure 3). This visit was financed by the US State Department as part of a training program for under-developed countries. DeBakey performed 8 heart valve surgeries in Ljubljana and invited several Slovenian experts to a training program in Houston, TX. In 1968, DeBakey transplanted a heart into a Slovenian boy, who went on to live for 8 more years, which was exceptional before the introduction of cyclosporine A in 1980 [Brecelj 2005]. Important cardiac surgeons to visit Slovenia also included Albert Starr, the co-inventor of the popular Starr-Edwards ball valve in 1974. Christiaan Barnard also visited Slovenia to promote the Slovenian translation of his book *Body Machine* (1981). In 1987, Philippe Menasché, a cardiac surgeon from Paris, performed the first surgical ablation of accessory pathways in a patient with Wolff-Parkinson-White syndrome together with a Ljubljana team (Brecelj, Rakovec) in Ljubljana. This marked the beginning of the surgical treatment of heart arrhythmia. More recently, the Ljubljana Division of Cardiac Surgery has also been visited by the following prominent surgeons: Magdi Jacoub and Ricardo Lima (the Royal Portuguese Hospital, Recife, Brazil), Stephan Schueler (Freeman Hospital, Newcastle upon Tyne, UK), Igor D. Gregorič (Texas Heart Institute, Houston, Texas, US), Sotirios Prapas (Henry Dunant Hospital, Athens, Greece), and Otoni M. Gomes (ServCor, Belo Horizonte, Brazil).

After 1975, cardiovascular surgery in Ljubljana began developing more rapidly, in part because the department moved into larger rooms at the new medical center building, which provided 65 beds for cardiac surgery patients. Increasingly more professional staff, especially nurses, were gradually employed. The new surgery unit and intensive care unit also contributed to the development of the department, but due to a shortage of funds they still had difficulty purchasing modern devices. Until 2000, cardiac surgeons managed the patients they had operated on by themselves, but afterwards their treatment was taken over by anesthesiology intensivists.



Figure 4. In 2003, Borut Geršak was the first in the world to introduce endoscopic aortic and tricuspid valve surgeries on a beating heart.

The 1974 establishment of the Pediatric Surgical Department including an intensive care unit at the University Medical Center accelerated the development of pediatric cardiac surgery in Slovenia. Under the leadership of Metka Derganc, methods of intensive treatment were introduced that met the professional demands of postoperative treatment of children who underwent heart surgery, especially newborns and babies. Pediatric cardiac surgery was taken over by Jolanda Jezernik Leskovšek, the head of the Division of Cardiovascular Surgery from 1988 to 1992; in 1980, she introduced perfusion and hypothermia procedures used during an infant's first year of life to Ljubljana and started repairing complex congenital heart defects in very small children from all over Yugoslavia. Safer and longer surgical procedures were enabled by the introduction of cardioplegia in 1975 to protect the heart muscle during surgery, and by the introduction of hypothermia in 1979. From 1993 to 2005, Miro Kosin headed the pediatric department and further developed techniques for primary complete surgical repair of congenital heart defects in the smallest infants and children, and introduced cavopulmonary anastomoses, electrical cardiac stimulation in newborns, and surgical procedures during extracorporeal membrane oxygenation (ECMO). In 2005, surgical activities were taken over by the Slovak cardiac surgeon Vladimír Soják, who performed surgeries for more than a year with the assistance of younger Slovenian colleagues. Since 2007, David Mishaly, a pediatric surgery specialist from Tel Aviv, has been training young cardiac surgeons at the Ljubljana University Medical

Center. Thus even the most complicated congenital heart defect surgeries, for which children previously had to be sent abroad (eg, switch surgery for congenital transposition of the great arteries and reoperations for children who had had operations for hypoplastic left heart syndrome abroad) started to be successfully performed in Ljubljana again. Ductus arteriosus ligations in incubators at the Division of Gynecology's maternity hospital intensive care department have become a routine procedure.

The beginnings of Slovenian cardiac transplantation reach back to the late 1980s, when Miro Košak and his colleagues began the first preparations for this procedure. Circumstances resulted in their performing a cardiac autotransplantation first. In June 1986, Košak performed a successful cardiac autotransplantation in a patient with a recurrent heart tumor: an allegedly benign myxoma that had been removed seven months prior to this procedure, but was later histologically diagnosed as malignant fibrous histiocytoma. It was only during surgery that it became clear that the tumor could not be removed from the heart in situ. This is why the operating surgeon explanted the heart and, after removing the tumor and reconstructing the missing atrial wall, reimplanted the heart. After the first electric shock, the heart resumed its normal rhythm [Juras 1986]. Slovenian cardiac surgeons reported this case in Yugoslavia [Košak 1987] and at the international cardiac surgery symposium in Rome in 1987 [Košak 1987].

The first cardiac transplantation in Ljubljana was performed by Tone Gabrijelčič and his colleagues in 1990. As of July 2008, a total of 72 cardiac transplantations had been performed. This transplantation activity is supported by a large medical team and the national transplantation network Slovenija Transplant, which was established in 1998 and joined the Eurotransplant International Foundation in 2000 [Gabrijelčič 1996].

Toward the end of the 1990s, the technological advances in cardiovascular surgery enabled the introduction of surgery on a beating heart in Ljubljana. At first, only revascularization procedures were performed on a beating heart, but later cardiac-valve surgeries also started being performed. Approximately 90% of all revascularization surgeries are now performed on a beating heart. This was followed by minimally invasive approaches (eg, ministernotomy and minilaparotomy, Tomislav Klokočovnik), and the introduction of endoscopic heart surgery in 2000. In 2003, Borut Geršak and his colleagues performed the world's first endoscopic aortic and, later on, also tricuspid valve surgeries on a beating heart, which he demonstrated in many European countries and in the US [Geršak 2003] (Figure 4). In 2006, surgical treatment of atrial fibrillation through radiofrequency ablation was introduced in treating patients who require heart surgery and suffer from atrial fibrillation [Geršak 2007]. Since November 2007, ventricular assist devices (VADs) have been used in patients with cardiac insufficiency as a bridge to transplantation or recovery [Zupanič Slavec 2008].

In the mid-1990s, the desire to provide more extensive assistance to Slovenian cardiac surgery patients also led to the introduction of cardiac surgery at the Maribor University Medical Center. From 1995 onwards, this was professionally

and organizationally managed by the Ljubljana cardiac surgeons, but since 2001 the Maribor center has been performing all heart procedures on its own, except for pediatric surgery. Slovenian cardiac surgeons perform approximately 2600 procedures a year.

In addition to their professional work, the Ljubljana cardiac surgeons also teach at the Ljubljana Medical Faculty. They serve as advisors to graduate students and take part in Slovenian and international research projects as well as form connections with the international cardiac surgery community. They are well aware that their work is closely connected with global developments and they thus accept findings from abroad and at the same time make their own findings internationally known. In medicine, which knows no national borders, Slovenian cardiac surgeons are also shifting boundaries.

In 2008, the Department of Cardiovascular Surgery had 137 employees: 11 surgeons, 5 surgery residents, and a junior researcher. Their professional work is supported by 97 employees in the nursing care unit.

DISCUSSION

The Ljubljana Department of Cardiovascular Surgery continually follows global trends in cardiac and vascular surgery and performs practically all of the procedures that are used throughout the world on a routine basis. It does not send its patients for surgery abroad. The expertise of Slovenian cardiovascular surgeons is at an international level; they train at the largest international medical centers, especially in the US (Houston, TX, Boston, MA, and Cleveland, OH), Germany, Japan, and Italy. They also participate as important coordinators in international projects financed by the European Union (www.ariser.info).

By following the discipline's international development and developing new surgical techniques and methods, the department has reduced the patient mortality rate in line with Eurocor standards, so that the present mortality rate is comparable with recognized international cardiac surgery centers. In addition, it has shortened the hospital stay of patients and reduced the total treatment costs. Increasingly more cardiac surgery patients also suffer from other diseases, especially diabetes. The coronary disease epidemic continues to be on the rise, and part of the pathology is treated by cardiac surgeons through invasive diagnostic procedures. In the last decade, pediatric cardiologists have started solving certain problems associated with congenital heart diseases in children alone without using surgery (ie, through the vessels).

CONCLUSION

Like elsewhere around the world, cardiac surgical activities in Slovenia have long since moved beyond the era of heroic cardiac surgery. Further development is based on the most precise, intellectual, and inventive work supported by robotics and the application of progenitor stem cells, a more daring approach to treating cardiovascular diseases, and close international cooperation. Surgeons are in constant search of the proper ratio between the benefits to the patient and the

risk of a surgical procedure. Their art lies in the ability to connect what is possible with what is conceptually better, as well as with the patient as an individual. At the conclusion of the congress marking the 50th anniversary of Slovenian cardiac surgery, which brought together the former creators of this discipline as well as numerous international experts and friends, special emphasis was placed on this aspect of Slovenian cardiac surgery.

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