Development of Congenital Cardiac Surgery in Toronto

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The development of congenital cardiac surgery required innovation by committed and talented individuals who integrated science, engineering and emerging medical knowledge while building a team of professionals dedicated to the care of patients. Life-long follow-up of these patients led to evolving management strategies to improve outcomes for neonates, infants, children and adults with congenital heart disease.

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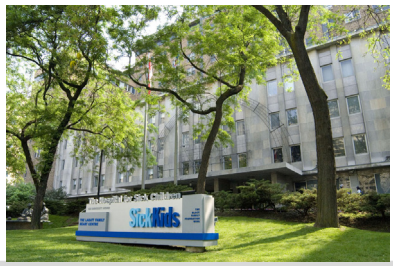

Hospital for Sick Children

Central Message

Congenital heart surgery has thrived at the Hospital for Sick Children in Toronto, evolving from an experimental level 65 years ago, because of brilliant individuals of diverse backgrounds working in a collegial environment that has fostered innovation in research and patient care.

> The key to innovation … realizing there is no conflict between nurturing individual geniuses and promoting collaborative teamwork… The Innovators: Walter Isaacson.

INTRODUCTION

Congenital cardiac surgery requires a dedicated collaborative team of many professionals who are committed to exemplary patient care. It follows that the development of congenital cardiac surgery was necessarily dependent upon numerous contributions from various people and research groups. Although much credit is given to specific individuals who became leaders in the specialty, the brilliance of these individuals was their insight to leverage the innovations of others in collaboration with their colleagues.

HEPARIN: AN ESSENTIAL PRECURSOR OF OPEN HEART SURGERY

Heparin was discovered by Jay McLean at Johns Hopkins in Baltimore in 1916. But it was not until 1935 that Charles Best (who with Banting and Collop was awarded a Nobel Prize for their discovery of insulin) perfected a technique for commercial production of heparin. The Connaught Laboratories of Toronto produced heparin. Connaught was created in 1914 by Dr FitzGerald, the first professor of Public Health at the University of Toronto, to manufacture rabies vaccine, diphtheria antitoxin, and later insulin, all provided free of charge. The first clinical use of heparin was April 16, 1935 at the Toronto General Hospital in a patient with deep vein thrombosis. A young vascular surgeon Dr Gordon Murray (1894-1976) supervised the care of this patient (Fig. 1). Murray subsequently demonstrated the efficacy of heparin in reducing the prevalence of pulmonary embolism. Murray went on to become a "highly imaginative and controversial pioneer in early cardiac operations in Toronto."[1]

Among Murray's accomplishments was the development of a renal dialysis machine in 1944, renal transplants, and early closed heart operations, including the Blalock-Taussig-Thomas operation during the 1940s. In 1956, Murray treated a patient with coarctation and aortic insufficiency by coarctation resection and end-to-end anastomosis of an aortic allograft as a valved tube, thereby relieving the coarctation and decreasing the effect of aortic insufficiency. A 15-year follow-up of this patient was reported by Kerwin et al.[2]

Murray proposed using heparin to manage arterial injuries. His junior colleague Dr William G. Bigelow (who later became chief of cardiac surgery at Toronto General Hospital and was a president of the American Association for Thoracic Surgery) was stationed in a forward military hospital in Europe during World War II. Murray provided Bigelow with a set of glass tubes and a supply of heparin with the intent of salvaging ischemic limbs of injured soldiers by bridging the arterial gap in a peripheral artery by interposing a glass tube and heparinizing the patient before evacuation to a base hospital. Bigelow did not have the opportunity to test the glass tube and heparin concept but he passed on the Murray protocol to his good friend and surgical colleague Major William Thornton Mustard (Fig. 2).

Major Bill Mustard did use the glass tube and heparin therapy in 3 of the 50 soldiers he treated with arterial injuries. He reported this experience in 1945 and declared the outcomes "….disappointing but not discouraging."[3]

The War provided Mustard with the opportunity to learn about arterial trauma and established an important precedent

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Figure 1. Gordon Murray, 1894-1976. First clinical use of heparin in April 1935 for management of venous thrombosis and prevention of pulmonary embolism. Reprinted with permission from *Neph Dial Transplant 1999; 11:2766-70*.

for his future career that experimental treatment should be reported honestly so that others may learn from novel experience. More about Dr Mustard later!

The "heparin story" in Toronto is an example of collaboration that, in retrospect, facilitated the development of open heart surgery. The clinical use of heparin arose from basic research, commercial production, and clinical research among collaborative individuals of diverse backgrounds and interests.

PEDIATRIC CARDIOLOGY: BUILDING A KNOWLEDGE BASE AND CREATING A PROGRAM STRUCTURE

Dr John D. Keith, a graduate of the University of Toronto in 1932, was the first division head of cardiology at the Hospital for Sick Children (Fig. 3). He created a catalog of all the children, whom he and his colleagues saw in consultation, including their outcomes. His textbook *Heart disease in infancy and childhood* (Keith, Vlad, and Rowe) was published in 1958 with subsequent editions in 1967 and 1978.[4] Their textbook became a standard for clinical diagnosis, natural history, and management. The international expertise of John Keith, Richard Rowe (who succeeded Keith as division chief), and Peter Vlad attracted a large

Figure 2. William Thornton Mustard, 1914-1987. Developed heart surgery at the Hospital for Sick Children, Toronto, beginning with the first open heart procedures in early 1950s and in 1963, an operation for physiologic correction of complete transposition of the great arteries. Reproduced with Permission of Hospital Archives, The Hospital for Sick Children, Toronto.

referral practice of patients with congenital heart disease and thereby the knowledge base to understand when surgical intervention was indicated.

A precedent set by John Keith and Bill Mustard was to manage patients together. Children were not "medical" or "surgical" patients; they were the cardiac program patients. Individual patient management was discussed by all members of the cardiac program at weekly clinical conferences and recommendations for treatment based upon best evidence at that time. This was "evidence-based knowledge" many years before Dr Gordon Guyatt coined the term in 1990 at McMaster University. The cardiac program's commitment to recording outcomes in every patient continually updated the "evidence". Clinical conferences were also supplemented by weekly pathology conferences and by daily cardiac catheter meetings.

Although Keith and Mustard were polar opposites in personality, their mutual professional respect and collegiality set a high standard for future generations of cardiac program staff, residents, and fellows.

EARLY HEART SURGERY: THE CLOSED HEART ERA

Dr W. T. Mustard was appointed to the surgical staff of the Hospital for Sick Children in Toronto in 1948.