Notable Grand Rounds
of the
Michael & Marian Ilitch
Department of Surgery

Wayne State University
School of Medicine

Detroit, Michigan, USA

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C. WALTON LILLEHEI: INNOVATOR, EDUCATOR, AND PIONEER

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About Notable Grand Rounds

These assembled papers are edited transcripts of didactic lectures given by mainly senior residents, but also some distinguished attending and guests, at the Grand Rounds of the Michael and Marian Ilitch Department of Surgery at the Wayne State University School of Medicine.

Every week, approximately 50 faculty attending surgeons and surgical residents meet to conduct postmortems on cases that did not go well. That “Mortality and Morbidity” conference is followed immediately by Grand Rounds.

This collection is not intended as a scholarly journal, but in a significant way it is a peer reviewed publication by virtue of the fact that every presentation is examined in great detail by those 50 or so surgeons.

It serves to honor the presenters for their effort, to potentially serve as first draft for an article for submission to a medical journal, to let residents and potential residents see the high standard achieved by their peers and expected of them, and by no means least, to contribute to better patient care.

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C. Walton Lillehei:
Innovator, Educator, and Pioneer

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Dr. "Walt" Lillehei (Fig. 1) was arguably the founding father of cardiac surgery,

Fig. 1. C Walton Lillehei (1918–99). *Source*: Banerjee, Ashis. "C Walton Lillehei (1918–99): the versatile pioneer of open-heart surgery." Journal of Medical Biography 16 (2008): 150 - 154.

making key contributions to medicine and cardiology. He once said, "Good judgment comes from experience, and experience comes from bad judgment." Essentially, he acknowledged that we all make mistakes and learn from them.

Cardiac surgery dates back to the 1930s and saw significant advancements in the 1950s with early cardiopulmonary bypass trials running alongside experiments in cross-circulation and hypothermic trials. Dr. Lillehei also coined the term for a crucial factor discovered during these times. He performed the initial dog lung trials, which led to the development of the high ox bubble oxygenator—a precursor to today's membrane oxygenator. Additionally, he created the world's first remote pacemaker. Later, he transitioned to Cornell University in New York City, where he began work on transplantation and concluded his surgical career.

Beginnings…

Dr. Lillehei was a Minnesota native, born in Minneapolis and stayed local for his education. He entered the University of Minnesota at the age of 16 to begin his undergraduate studies in pre-medicine, initially considering dentistry before choosing medicine. He completed both his undergraduate and medical degrees at the University of Minnesota, staying on for his internship.

When World War II broke out in 1942, he was deployed to Northern Africa as a surgeon, operating out of a field hospital tent. Over two and a half years in the Army, he was promoted to Lieutenant Colonel and commanded the 33rd Field Army Hospital. After his military service, he returned to the University of Minnesota, where he met Dr. Owen Wangesteen, the Chief of Surgery. Dr. Wangesteen, who had been in his role for about 25 years, also served as the residency program director. He interviewed Lillehei, who was then admitted to the residency program—his first choice.

Lillehei's primary research at the University of Minnesota involved using dogs to study open-heart surgery. Known for being as comfortable in the operating room as he was socializing in smoke-filled nightclubs, Lillehei was also a noted socialite. His primary interests at the university were aligned with Wangesteen's principles, which emphasized a balance between clinical duties and research. Unlike many contemporaries, Wangesteen required his residents and staff to devote equal time to clinical work and research, a philosophy that facilitated pioneering techniques in open-heart surgery.

…and a near-Ending

In 1946, Walton Lillehei started his residency after completing an intern year before the war, followed by two years of clinical duties and an additional two years in the lab. During his training, he developed a facial lesion in his final year, which was evaluated by Wangesteen, a surgical oncologist known for his radical debulking approach, who suggested a biopsy of the lesion. The initial pathology report diagnosed it as lymphosarcoma. Intriguingly, Wangesteen, who was also the department director and Lillehei's operating surgeon, did not inform Lillehei of his diagnosis. Lillehei spent nearly a year unaware that he had been given what was essentially a death sentence. Upon completing his training, Wangesteen disclosed the diagnosis, informing Lillehei that his survival chances over the next five years were less than 10% with the current therapies. Despite this, Lillehei survived beyond five years and maintained a close friendship and professional relationship with Wangesteen.

Wangesteen's preferred treatment method involved a large incision and radical debulking. Thus, Lillehei underwent a radical neck dissection and a sternotomy, which involved opening the mediastinum. The operation was challenging, with significant blood loss. Remarkably, departmental colleagues, including Norman Shumway, a leader in cardiac transplantation, donated blood to help save Lillehei's life. This act of camaraderie exemplified the support within the department. Lillehei also underwent radiation therapy, which led to an infected median sternotomy wound, requiring him to undergo dry dressings for several months.

Return to Academia

Upon his return to academia in 1950 at the University of Minnesota, Lillehei brought with him a unique perspective shaped by his personal hardships, pain, and fear—experiences many surgeons had not faced. This distinct approach influenced his interactions with patients. By the 1950s, he had established the foundation for modern cardiac surgery through his forward-thinking, insatiable desire for knowledge, and perseverance in the face of ethical and moral challenges that deterred many of his contemporaries.

Cardiac Surgery Before the 1950s

To understand the progress in cardiac surgery leading up to the early 1950s, we need to examine the developments of the time. The overarching goal was to safely open cardiac chambers, a task fraught with peril as multiple attempts by various surgeons had uniformly ended in fatality. The attempt to open the living heart often resulted in a catastrophic loss of blood, likened to a river running dry.

The state of affairs in cardiac surgery history began to shift with significant advancements. The first real milestone operation was performed in 1938 by Robert Gross at Boston Children's Hospital, involving the ligation of a ductus arteriosus. This procedure established a standard that continues to this day.

In 1943, the legendary Alfred Blalock at Johns Hopkins created what has since become known as the Blalock-Taussig-Thomas (BTT) shunt, initially intended to treat babies with Tetralogy of Fallot, which involves a right-to-left shunting of blood. This procedure was a simple bypass connecting the subclavian or carotid artery to the ipsilateral pulmonary artery, effectively decompressing the right-to-left shunt and allowing deoxygenated blood to circulate through the lungs, thus resolving hypoxemic deficits.

During the 1940s, other pioneering efforts were made by Dwight Harken at Harvard and Charles P. Bailey at the University of Pennsylvania. They developed closed heart techniques, such as the blind mitral commissurotomy, primarily to treat mitral stenosis resulting from rheumatic disease. This technique drew on Harken's wartime experiences.

Harken, like Lillehei, served as a surgeon during World War II. His notable first case involved treating a soldier with a penetrating cardiac injury. The soldier was brought in with an X-ray showing shrapnel lodged within the myocardial wall. During the sternotomy, Harken discovered a free ventricular perforation. He was able to stop the bleeding by inserting his finger through the perforation created by the shrapnel, palpated the inside of the ventricle, retrieved the shrapnel manually, and subsequently closed the ventricular wall. His treatment of this case and subsequent others—totaling 134 soldiers—laid the groundwork for closed heart techniques and inspired the development of the blind mitral technique.

Harken adapted these experiences to treat mitral stenosis, while Charles Bailey followed suit in Pennsylvania. These two were among the leading figures in the field. Their success fueled the ongoing desire and hope that eventually, open heart techniques would not only be feasible but also widely practicable.

Fig. 2 is a rendition of the BTT shunt. If it's on the right side, it would need to connect the right subclavian artery to the right pulmonary artery, and on the left, it would connect the left subclavian artery

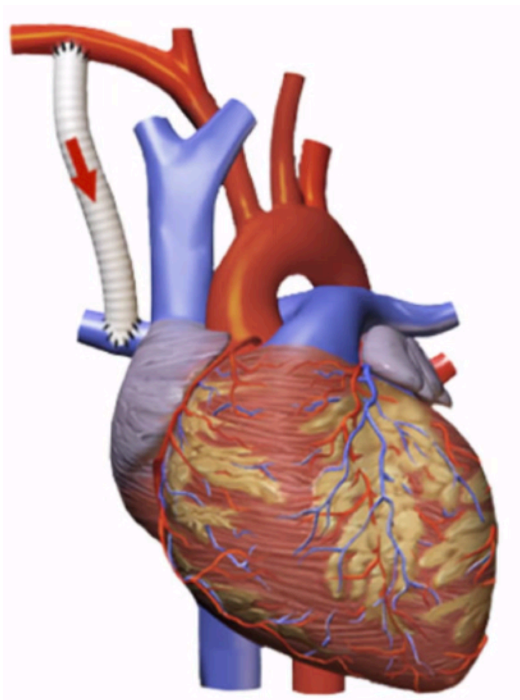

Fig. 2. Diagram of a modified Blalock Taussig Shunt, with a synthetic graft from the Right Subclavian artery to right pulmonary artery.
Source: Gaillard F, Hacking C, Yap J, et al. Blalock-Taussig shunt. Reference article, Radiopaedia.org (Accessed on 05 Jun 2024) https://doi.org/10.53347/rID-8485

to the left pulmonary artery. This operation, pioneered in 1943, is a significant part of the history of cardiac surgery.

As the 1940s progressed, our understanding of the cardiac chambers and valves was still primarily based on autopsy specimens. We can recall the quote, "To open the heart was to kill the patient in a river of blood that ran dry in less than a minute." This led to discussions about the need for a better way to isolate the vasculature to limit blood flow through the heart, which would allow surgeons to actually see and potentially fix the issues.

Harken' progress with closed techniques continued to provide hope. By the late 1940s, major institutions like the University of Pennsylvania, Harvard, Mayo Clinic, University of Toronto, University of Minnesota, Hopkins, and others believed that a cardiopulmonary bypass circuit was necessary to successfully perform open heart operations. Most institutions had a prototype, often designed by the operating surgeons at the institution.

Early CPB Trials

Being curious and somewhat relieved after his postoperative recovery, Dr. Lillehei visited several institutions to familiarize himself with their surgical techniques and their current bypass pumps. He noted that all the designs were exceedingly complicated and none had achieved good success. This included his colleague at the University of Minnesota, Dr. Clarence Dennis. Dennis was at the forefront of developing a pulmonary bypass circuit at the University of Minnesota, based on blueprints borrowed from Dr. Gibbon.

The initial trials at the University of Minnesota were led by Clarence Dennis, who was heading the department's efforts in developing the circuit. Lillehei was present for the second trial run; he had been out on leave during the first trial due to his operation. At this time, the goal was to try and fix ASDs (Atrial Septal Defects), as these were simpler targets that required less operative time.

Clarence Dennis was conducting pioneering work with patients to correct ASDs. On April 6, 1951, he utilized a pulmonary bypass circuit on a human outside of laboratory research for the first time ever. Unfortunately, during this procedure, it was discovered that the patient had an AV canal defect and Tetralogy of Fallot, which could not be repaired, and the patient expired intraoperatively.

It's important to note that at this time, heart catheterization had not yet been developed; this came later in the 1950s. Interestingly, the physician who developed the technique catheterized himself to demonstrate its feasibility. He advanced a catheter into his heart and, during the procedure, passed out after triggering a ventricular response—an event captured on an X-ray.

Dr. Dennis's first patient expired due to an incorrect diagnosis; at the time, diagnostic tools were limited to chest X-rays and physical examinations. The second patient, observed by Lillehei, also expired on the operating table from an air embolus. During this operation, which Dr. Varco assisted in, it was noted that the patient's coronary and central circulations were filled with air. This was attributed to a failure in the pump operation where one of the operators had not filled a reservoir properly, introducing air into the circuit.

These early attempts underscored the complexity of the cardiopulmonary circuits used at the time. Dennis's circuit required a team of sixteen people just to operate it, excluding the surgical and anesthetic staff. This cumbersome setup was one of Lillehei's significant criticisms of Dennis's work.

Another major figure in this era was Dr. John Gibbon, who was among the first to develop a cardiopulmonary bypass circuit. Gibbon shared his blueprints with Dennis, who then made modifications and utilized them at the University of Minnesota. This collaboration and exchange of ideas were crucial in the evolution of cardiac surgery techniques.

In early 1951, Dr. Gross, who had previously performed the first PDA ligation at Boston Children's, was working on a technique to repair ASDs. He devised a method involving a reservoir that would connect to the heart, allowing for an atrial atomy. This setup was intended to enable the surgeon to sew underwater, fixing the ASD by palpation alone. Although Dr. Gross managed to fix a few ASDs with this method, it never gained widespread acceptance due to its limited success.

During this time, Lillehei was recovering from his operation and traveled around the Northeastern U.S., visiting other surgeons and observing their work and research in their laboratories. ASD repair remained a primary focus, with most of the modeling for these defects still reliant on autopsy specimens.

John Gibbon was arguably the first to begin working on a cardiopulmonary bypass circuit by 1951, having spent over a decade on the project with little to show for it. His first patient operation using the circuit was in May 1953. This operation, which successfully repaired an atrial septal defect, marked the first successful open-heart operation using a pump oxygenator. However, the subsequent operations were less successful; out of four patients, three died intraoperatively, resulting in a 75% mortality rate. Discouraged by these outcomes, Dr. Gibbon, like Dr. Dennis, decided to abandon cardiac surgery due to moral and ethical concerns.

Hypothermic Trials

Simultaneously, while Lillehei was traveling, he also visited the University of Toronto, where he met Dr. Bigelow, who was achieving notable success with hypothermic trials in dogs. Dr. Bigelow demonstrated that dogs could tolerate long periods of total vascular isolation (involving the central pulmonary artery,

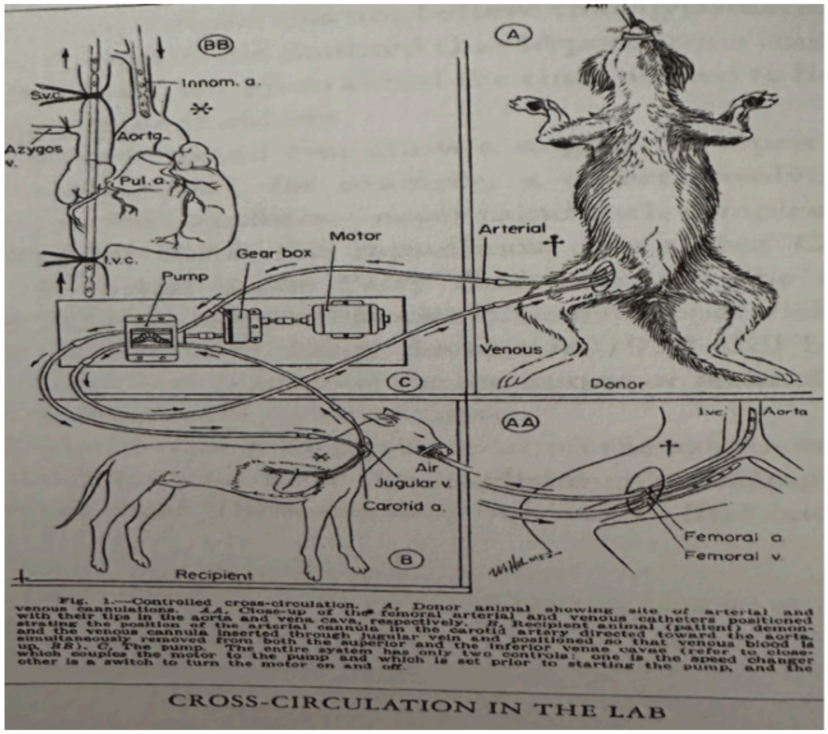

Fig. 3. Diagram of the experimental technique for controlled cross circulation.
Source: https://gallery.lib.umn.edu/exhibits/show/openheart/cross/oxygenation

aorta, IVC, SVC) with temperatures dropped to between 20 and 27 degrees Celsius. Upon rewarming, the dogs showed no neurologic deficits, proving the success of the procedure. However, Dr. Bigelow struggled to receive patient referrals from cardiology or medicine due to the experimental nature of his work, which was still limited to dog studies.

Recognizing the potential of hypothermic trials, Lillehei brought this knowledge back to the University of Minnesota, contributing further to the evolving field of cardiac surgery.

John Lewis, a year senior to Dr. Lillehei at the University of Minnesota, was greatly impressed by the hypothermic trials. In 1952, before Gibbon's work in 1953, Lewis performed what is considered the world's first successful open heart operation. This procedure, an ASD repair, took place in five and a half minutes under hypothermic isolation. The patient's body temperature was lowered, the heart was quickly opened and closed, and then the body was warmed and tourniquets released. Although not the lead surgeon, Lillehei did assist Dr. Lewis on this pioneering operation. At that time, Lillehei was more focused on what he termed the "azygos factor," (about which more later).

Lewis continued with his hypothermic trials for several years. However, a significant challenge arose with ventricular septal defects (VSDs), which required more time to fix than was feasible under hypothermic conditions. This limitation led Lewis to conclude that he could not successfully repair VSDs using his current method.

Meanwhile, Lillehei believed that while cardiopulmonary bypass was necessary, the existing research and engineering were not yet advanced enough to make it feasible. Therefore, he explored other types of perfusion methods, including something unique called cross circulation, which only he was successfully able to perform.

Cross Circulation

An article in the British Medical Journal[1] demonstrated that dogs could tolerate up to two hours of total vascular isolation with no neurological deficits, noting that blood flow through the azygos vein was the only circulation. Lillehei, inspired by this, conducted his own dog studies to test if a dog could survive with only 10% of normal blood flow. The results were positive; the dogs woke up fine, confirming that prolonged survival was possible under these conditions.

To further validate these findings, Lillehei operated on prize purebred Golden Retrievers, chosen because their ability to perform tricks would clearly demonstrate the absence of neurological deficits post-operation. The dogs performed as expected after the surgery, paving the way for applying these findings to human models.

Lillehei's innovative approach involved using one animal to supply blood to another during surgery (Fig. 3). This method of perfusion, based on the "azygos factor," involved peripherally cannulating the donor animal through the femoral vessels and centrally cannulating the recipient through the neck. Blood was transferred from the donor to the recipient, effectively using the donor's circulation to maintain the recipient during surgery.

This cross-circulation technique was groundbreaking, and Lillehei presented his positive results with animals at a 1953 symposium. He demonstrated that dogs could tolerate prolonged vascular isolation with 10% of normal blood flow without neurological effects, and that they could withstand the cross-circulation setup. Dr. John Gibbon, who was initially critical of Lillehei's methods, questioned the ethical and moral principles behind these experiments, especially as he presented his own less successful case series just before stepping away from cardiac surgery.

Upon returning to Minnesota after the conference, Lillehei was resolute in pursuing cross-circulation trials. After completing their experiments with dog models, they transitioned to human applications. They chose to use a Model TS6 pump, specifically a milk pump, due to its ability to generate bidirectional flow at consistent rates and volumes. Importantly, this type of pump did not agitate the fluid excessively, thereby avoiding the creation of harmful air bubbles—a known cause of fatalities from air embolism in previous surgeries.

To ensure the apparatus was suitable for medical use, they sterilized the milk pump and then faced the challenge of selecting appropriate tubing. They opted for clear plastic beer hose, which they also sterilized, allowing them to monitor for any air within the system—a critical factor in ensuring patient safety. Thus, the cross-circulation setup was inge-

[1] A. T. ANDREASEN, CROSS-CIRCULATION, British Medical Bulletin, Volume 11, Issue 3, 1955, Pages 233–235, https://doi.org/10.1093/oxfordjournals.bmb.a069500

niously configured using a combination of a milk pump and beer hoses.

They conducted tests with 17 pairs of dogs, running the cross-circulation system for 30 minutes. These trials were largely successful, with only one pair experiencing complications due to a configuration error in the circuit, not an inherent flaw in the cross-circulation concept itself. Lillehei was encouraged by these outcomes and tested the system further by creating VSDs (Ventricular Septal Defects) in dogs and then repairing them. His success in these canine models provided the impetus to consider human trials.

Despite these advancements, Lillehei faced considerable challenges within his institution. He was up against the more senior Dr. Lewis, who continued to pursue his hypothermic trials despite having no success with VSDs. Furthermore, there were ethical and moral concerns surrounding his methods, notably from Dr. Gibbon. Dr. Gibbon, who had been outspoken against Lillehei's approaches, eventually stepped away from the field due to his own failures.

These internal and external pressures did not deter Lillehei, who pushed forward with his innovative techniques, demonstrating a blend of scientific ingenuity and boldness in the face of controversy and skepticism within the medical community.

Lewis, in 1954, received permission from the department chairman, Wengensteen, to perform the first VSD repair at the University of Minnesota. Lillehei, somewhat devastated by this decision, chose to step away temporarily and traveled to Rochester, Minnesota. There, he met with a pathologist at the Mayo Clinic, which housed the world's largest volume of anatomic specimens due to its policy of never discarding autopsy samples. With Dr. Edwards, Lillehei studied various VSDs at the Mayo Clinic, practicing both primary and patch repairs on the hearts.

Upon returning to Minnesota with newfound confidence, Lillehei was ready to tackle VSD repairs himself. However, his colleague, Dr. Lewis, attempted the repair under hypothermic conditions and failed. This failure opened the door for Lillehei's first cross-circulation VSD repair on March 26, 1954. The operation involved a father as the donor and his child as the recipient. Although the child survived the surgery, it died eight days later from pneumonia. Concerned that this complication might jeopardize future operations, Lillehei performed an autopsy, confirmed the cause as pneumonia, and was allowed to continue his work.

As 1954 progressed, Lillehei's success grew. He not only pioneered cross-circulation and performed the world's first verified VSD closure, but he also began tackling more complex cardiac defects. Despite criticism over the ethical and moral implications of endangering two lives instead of one with cross-circulation, Lillehei's work demonstrated significant success. However, heart block remained a challenge—if the conduction band was interrupted during VSD repair, there was no way to save the patient.

Lillehei's perseverance was evident in his approach to solving complex cardiac issues. Unlike others who retreated after initial setbacks, he was determined to find solutions, successfully repairing the world’s first AV canal defect on his second attempt after a mishap during the first.

Lillehei’s focus then shifted to adapting his techniques for larger patients and more complex cases. This need led him back to the concept of a membrane oxygenator or a pump as essential for advancing cardiac surgery.

DeWall-Lillehei Bubble Oxygenator

In 1954, Lillehei met Dr. Richard DeWall, a family practitioner who had developed a prototype of an artificial heart valve. After being introduced by Dr. Varco, Lillehei and DeWall quickly began collaborating on developing their own bubble oxygenator. DeWall transitioned from family practice to becoming a lab assistant and surgical assistant, significantly altering his career path to work alongside Lillehei in groundbreaking cardiac surgery.

This narrative showcases Lillehei's pioneering spirit and his relentless pursuit of advancing cardiac surgery, despite facing numerous challenges and criticisms along the way.

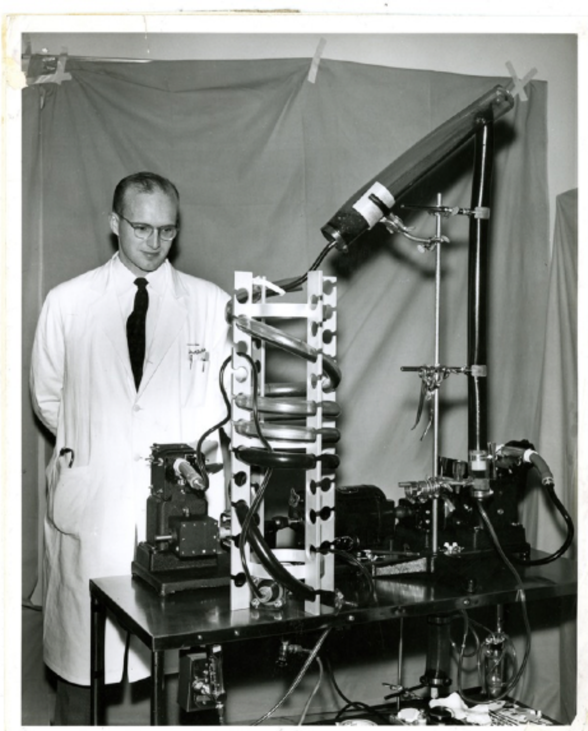

Fig. 4. Richard DeWall and "bubble oxygenator" heart-lung machine 20 Nov 1956
Source: https://gallery.lib.umn.edu/exhibits/show/

In essence, Lillehei realized the necessity for a more effective cardiopulmonary bypass system that could accommodate larger patients and allow for extended operative times. One day, while discussing this need over beers with Dr. DeWall, they observed the behavior of bubbles in their drinks. Noticing that smaller bubbles dissipated less readily than larger ones, they deduced that a blood reservoir needed (1) to be infused with large oxygen bubbles only and (2) to pump blood from the bottom of the reservoir, allowing the large bubbles to rise and dissipate at the top of the reservoir, thereby preventing air embolism.

This observation led to the development of what they called the DeWall-Lillehei oxygenator (Fig. 4). They used a simple glass reservoir sealed with a rubber stopper, through which they inserted 18 needles connected to an oxygen tank, bubbling oxygen through the blood. This method, which used larger needles to create bigger bubbles that dissipated more effectively, was not only straightforward but also cost-effective, totaling only $15 to create. This simplicity and low cost significantly contrasted with the more complex devices of the time.

The DeWall-Lillehei bubble oxygenator proved to be a massive success. It facilitated the repair of VSDs among other cardiac abnormalities and was crucial in operations on larger patients. Its effectiveness and affordability drew attention from prominent figures in the cardiac surgery community, including Dr. Denton Cooley and Dr. Michael DeBakey, who adapted and promoted Lillehei's innovation. From 1955 until the late 1970s, the DeWall-Lillehei oxygenator became the global standard.

The Pacemaker

Additionally, Lillehei made significant strides in the development of cardiac pacemakers. He noted that heart blocks were often lethal because there was no way to manage them effectively at the time. Inspired by early external pacing electrodes developed by Dr. Zoll, Lillehei experimented with placing pacing electrodes directly on the heart. After successful trials in dogs, he applied this method to human patients, developing an external but direct method of stimulating the heart to overcome heart blocks. This approach led to the first series of epicardial pacing, where a silver-plated copper wire was attached to the heart's surface. The device was kept in place until the patient’s native rhythm resumed, after which it was removed.

The initial pacing systems were cumbersome, involving lengthy electric cords that had to be carefully managed to ensure continuous operation. This setup required a coordinated effort by several nurses to manage the cords as patients were moved from the operating room to the ICU. Recognizing the impracticality of this system, Lillehei sought to develop less cumbersome and more reliable solutions. This pursuit underlined his continuous effort to innovate and improve cardiac care, solidifying his status as a pioneer in the field.

In 1958, Lillehei met Earl Bakken, a pivotal figure in the development of medical devices, though not widely known outside of specific circles. Bakken, a TV repairman from Minnesota, collaborated with Lillehei after the latter's initial success with the pacemaker. Together, they created the world's first portable, battery-powered pacemaker. This innovation laid the groundwork for the development of the implantable pacemaker and, eventually, the implantable pacemaker-defibrillator that are commonly used today.

Bakken went on to found Medtronic, a major medical device company, with Lillehei not only as a founding father but also as a significant financial investor. Their collaboration began with the development of the initial battery-powered pacemaker in 1958, marking a significant advancement in medical technology.

By the 1960s, Lillehei had completed over 1,000 open heart operations using the bubble oxygenator, which remained the global standard until the late 1970s.

Heart Valves

His pioneering work didn't stop at cardiac surgery; he also contributed to the design and development of artificial heart valves. He created four different valves, three of which were for St. Jude Medical, where he served as medical director. The initial one was the Lillehei-Kaster valve, a tilting disc valve that was one of the first of its kind.

Lillehei's achievements were recognized with the Lasker Prize for his work on cross-circulation trials—a prestigious award often considered the American equivalent to the Nobel Prize. Although he was a Nobel nominee, he never won the award, primarily due to the moral and ethical concerns associated with cross-circulation techniques, which some felt overshadowed his significant contributions to cardiac surgery.

Move to Cornell

Lillehei remained at the University of Minnesota until 1967. He left following the departure of Owen Wangensteen, the department chairman, due to a disagreement over the direction of the department and other internal conflicts. Lillehei then moved to Cornell University in New York, where he took a position as Chief of Cardiac Surgery at New York Hospital. He abruptly moved his lab equipment from Minnesota to New York in the middle of the night, leaving a red rose in the middle of the floor of his laboratory as a remembrance.

Transplantation

At Cornell, Lillehei shifted his focus to transplantation, leveraging the expertise he developed in Minnesota. He collaborated with Dr. Christiaan Barnard, a South African surgeon who trained under Lillehei at the University of Minnesota. Barnard became the first surgeon to perform a human heart transplant. Lillehei's influence extended to other prominent figures in cardiac surgery, including Norman Shumway, another leader in cardiac transplantation.

Through these efforts, Lillehei not only pushed the boundaries of medical technology but also shaped the careers of other influential surgeons in the field of cardiac care and transplantation.

Dr. Christiaan Barnard's initial impression of Lillehei at a holiday party was that he was too much the jovial socialite, which initially gave Barnard pause. However, his opinion shifted significantly after observing Lillehei's focus and expertise in the operating room. This transformation underscores the complex persona of Lillehei, blending his social flair with surgical brilliance.

Lillehei's career continued to evolve in New York City at Cornell, where he performed the world's second successful heart-lung transplant in 1969. Although the first patient died of rejection shortly after the surgery, Lillehei's pioneering work did not wane. He was notably the first to transport a donor heart between facilities for a transplant, from Memorial Sloan Kettering to Cornell Hospital. This operation was groundbreaking, also allowing the donor to contribute organs to six other patients. However, this practice faced significant ethical debates, though Lillehei managed to navigate these challenges despite ongoing criticism.

The success of transplantation during this period was hindered by inadequate immunosuppression techniques, reflecting the broader challenges in the field. Administrative discomforts at Cornell, combined with controversial personal behaviors and federal tax charges, culminated in Lillehei stepping down as Chief of Surgery in 1970 and eventually facing professional repercussions, including the suspension of his medical license in Minnesota and his position with the American College of Surgeons.

Retirement from Surgery

Despite these setbacks, Lillehei continued to influence the field of cardiac surgery. After retiring from surgical practice due to developing cataracts, he returned to Minnesota and resumed his role as a medical director at St. Jude, contributing significantly to medical education and research. His legacy was further solidified as his reputation recovered and he was eventually re-invited to lecture across the United States, despite initial restrictions due to his legal issues.

Lillehei's impact on cardiac surgery is profound, having trained at least 138 cardiac surgeons. His career is a testament to the complexities of merging pioneering medical innovations with personal and professional challenges. His journey is encapsulated in the wisdom that "good judgment comes from experience and experience comes from bad judgment," a reminder of the human capacity to learn, adapt, and innovate despite imperfections.

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