

History of Perfusion

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FROM COUNCIL BLUFFS, IOWA TO HUTCHINSON, MINNESOTA—MAPLEWOOD ACADEMY TO THE UNIVERSITY OF MINNESOTA

Early one day, I walked over to the University of Minnesota to sign up for pre-med. While waiting, I picked up the school newspaper and saw an ad for pre-med and dental students to work in surgery during the summer. I thought this would be a good way to find out if I could stand the sight of a lot of blood. After a short training course on sterile protocol, instruments, sutures, and surgery cases, I felt that I had “hit the jackpot.” We rotated through operating rooms with experienced OR nurses, and I was meeting all of the visiting surgeons from around the world. (I don’t know if the University of Minnesota police had detectives check us out. I do know they did on post-operative heart patients. They trusted us with cocaine used in eye and ear surgery.)

There were no angiograms, no echocardiograms. There were no coronary care units, no MRIs (Magnetic Resonance Imaging). There were no intra-aortic balloon pumps, LVADs (left ventricular assist devices), or Bi-VADs (biventricular assist devices). There were low-power defibrillators.

SURGEONS—SCIENTISTS

Dr. Owen H. Wangenstein

Dr. Owen H. Wangenstein was chief of surgery at the University of Minnesota. Only 31-years old, he was the youngest chief ever at any university. He was gifted with a photographic memory and famous for “Wangenstein suction” that would hold a negative pressure in chest wounds in MASH units in World War II. We used this on heart patients in postsurgery. Using very long electric cords to go from Room J to the recovery room, we moved the patient and what few monitors we had, while the orderlies let out electric cords and made sure there were no mishaps. Thankfully, batteries were eventually used for those procedures. (If only they had had a Heimlich valve. I’m surprised no one thought to use a “duck call” with the



one-way feature. When Dr. Wangenstein said “No,” a surgeon, not even Dr. Lillehei, could operate. Dr. Owen Wangenstein’s family had problems with alcohol and substance abuse. A young salesman could never get an order from Dr. Wangenstein for his products and complained about this to one of his competitive colleagues. His “friend” told him to take a case of the best Irish Whiskey to Dr. Wangenstein. The first salesman did and was never allowed in the hospital again.)

Dr. C. Walton Lillehei

General practitioners of the 1950s and 1960s “pilled their patients to death” (rather than send them to Dr. Lillehei) until the patient actually was near death, when the families would finally bring them to Dr. Lillehei. We found that family MDs thought they would lose all of their patients to the big city. When Dr. Lillehei finished his morning caseload, he had to get to the airport to fly to meetings with MDs in three or more states. He was usually running late. However, the pilots told the passengers why the flight was delayed, and Dr. Lillehei would receive a standing ovation when he finally boarded the plane. When he spoke to the MDs, he gave the doctors a full Grand Rounds Session, let them know about their successes, and how soon their neighbor(s) would be home, back to their family doctor, and won their trust. With these trips, more patients survived. There was a 2-week period without any survivor. I would wake up at night and wonder if I had forgotten something. I could put the pump and all the components together in my mind. Fortunately, or unfortunately, it was not anything that we had forgotten; we just

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had a run of very sick patients. Jim Wade, the second president of AmSECT, kept delaying his cardiac surgery because he did not know of the low risk attributable to improved technology and procedures. (Once, when Dr. Lillehei heard the rubber plug pop out of the helix coil, he turned to me and said, "I guess we were lucky it didn't happen during bypass." Residents had to do a rotation with me because many would go back to their countries. I stationed them on the suction side of the oxygenator. One day, Dr. Farouk Fataw went to sleep on the stool, fell onto the floor, and was sent home. Dr. Lillehei did not say a word.)

Dr. Richard Varco

(I scrubbed up for Dr. Richard Varco, and he asked me if I had ever had my finger in a child's heart. I answered, "No." He took my hand in his and guided my finger into the hole in the heart. I knew this was amazing because Dr. Varco's fingers were very large. He had to use long forceps to operate. He was a perfectionist. He was already known as one of the best cardiac surgeons in the US [page 129].) Despite his temperament, he was a great teacher. He would go after interns, residents, and even chief residents, making them go to the library and come back with the correct anatomy, "or else." He even "educated" pump techs in the same manner. The pump noise was loud, and the heat exchanger was slow in warming up a child, so I would start early to warm because I got the sign from the chief resident. I thought I heard Varco say, "start warming," so I did. Then he yelled at me, "the heart has started!" and how was he to suture? I told him I was sorry, which was the wrong thing to say. He closed the beating heart and left the room. He came back, sat down next to me, and asked me how he would know how sorry I was? I told him it would not happen again. (I would have had Dr. Varco operate on my sons or family members, if needed, back then.)

I would take Dr. Varco's calling cards, give them to parents of children with blue fingernail beds (also "blue babies"), and suggest that Dr. Varco might be able to help their children. VSDs (ventricular septal defects) and ASDs (atrial septal defects) became so routine that we dubbed them "gravy train runs." I loved to hear those babies cry and see their pink fingernail beds and faces.

In Chicago, we successfully operated on a father and son. The dad wanted his son to go first, and the son was in and out in just a few days. The dad took longer because he was an alcoholic. On the day the father was released, we had a nurse stand between the boy and the dad. The nurse was actually helping the dad to stand up. Their picture made the front page of the newspaper the next day.

Dr. Richard DeWall

When Dr. DeWall invented the bubble oxygenator, the

University of Minnesota held the patent for DeWall's inventions; the University of Minnesota also held the patents on the Travenol bag oxygenator; Dr. DeWall did not receive a dime. He worked with General Mills on a four-ply bag oxygenator. Outer ply for heat exchanger and inner plies for blood and gas, but there were a lot of leaks and poor heat exchange.

We moved to Chicago and back to open-heart surgery. DeWall was at it again, developing an oxygenator with a built-in heat exchanger. He offered it to Travenol, but they were selling a lot of bag units. He traveled to Edwards Labs in California, but they also said no. We found out later they were working on the Landy-Edwards membrane oxygenator. (I called it "the battery.") Back at Edwards, there was a young engineer who thought it would work. His name was Jim Bentley, and the rest, as they say, is history.

Dr. Willem Kolff

Dr. DeWall had me attend the artificial organs meeting in Atlantic City so I could check on equipment for our labs and heart cases. He would not talk to sales representatives. I was there to meet with Dr. Kolff about his membranes for kidney dialysis. I was also looking for members for AmSECT and kidney techs. I asked Dr. Kolff if it would oxygenate blood, and he said it would, but not enough to work in the sausage casing for heart-lung use. We also talked about his ingenious way of using beer cans to smuggle the dialysis plans out of Holland. We met again in Cleveland, where we held AmSECT's third meeting. Dr. Kolff had switched to flat plates of thick plastic with membranes between each layer.

Charles Lindbergh

Charles Lindbergh's sister-in-law's heart disease prompted him to think: If we can change valves in cars and airplanes, why not in humans? If my memory serves me correctly, Charles did build a heart-lung machine. What component or components were missing? What was it and what country's scientists solved the problem?

The missing components were:

- *sodium heparin-beef lung and porcine mucosa*
- *protamine sulfate, sperm of salmon and certain other fish*

Dr. Oust

All of the heart team could make remarks or constructive criticism concerning the heart-lung machine. We did not take wisecracks or putdowns by outsiders as we were making improvements all the time, but only one at a time. Dr. Oust's claim to fame was performing hemipelvectomy on cancer patients; which saved lives. However, he had this habit of showing Polaroid pictures of his patients swinging on metal bars over their beds. Dr. Oust came into

OR-6 where Dr. Aldo Castaneda was opening the child's chest and ignoring Dr. Oust's remarks about a "Rube Goldberg piece of junk." I thought Dr. Oust had left the room. While working on the pump, I asked Aldo, "If Dr. Oust was so smart, where was his heart-lung machine?" There was total silence. I looked up in time to see Dr. Oust hit the button for the other exit door, and he never bothered us again.

Daily Routine

Every morning, I had to scrub in, cut the tubing, and connect the four stainless steel connectors to the pump head. Four more connectors were attached to the "suckers," four more for the arterial line and the return line. I would scrub out and assemble all the parts of the oxygenator and pumps. I used white hospital tape to secure the connectors with many wraps to prevent the pump housing from "walking" or splitting the tubing. The defoaming chamber (cotton ball cannister) was preassembled and wrapped with green hospital surgical drapes, then sent to the hospital's large sterilizer. Afterward, I would be paged to the front desk to get the demand pacemaker from Earl Bakken. Earl, founder and CEO of Medtronic, worked for the University of Minnesota as an engineer and would tell me the setting for the pacemaker.

COMPONENTS FOR THE FIRST BUBBLE OXYGENATOR SYSTEMS

- *pump head tubing was clear beer hose*
- *mayon plastic for other sizes, used for mayonnaise products. There were specific oxygenator tubing lengths for adults and children to allow for different dwell times*
- *sigmamotor pump Model T-6S, used in the dairy industry and chemical plants to move chemicals; It cost \$500 and operated using a sine-wave motion; it was loud and noisy; there were metal plates on each side of the tubing; damaged red cells = pink urine*
- *the blood-gas disperser contained 18 holes the size of standard intravenous needle; the disperser was held in place by a custom-made housing (we switched to a Jensen housing that held the disperser); the blood would then go up the Mayon tubing to the defoaming chamber; this goes to the black plug outflow of the helix coil*
- *the defoaming chamber—somewhat larger than a cotton ball dispenser, the blood entered the bottom of the cannister and dispersed into the nylon mesh and stainless steel Gottschalk sponges coated with Dow-Corning Antifoam-A, then into the helix coil that also acted as a Venturi vent; we also had a fitting that we attached to the side in a u-shaped loop to monitor the blood level in the defoaming chamber; in case of a very long surgical case, we could spray Antifoam-A directly into the defoaming chamber*

- *Gottschalk stainless steel sponges, used to clean cream separators. Each sponge was a continuous band to prevent particle emboli. Washed withalconox soap to remove any oil from the manufacturing process.*
- *Dow-Corning Antifoam-A and ether added and jar capped for 2–3 days (the jar originally held catgut sutures), then decanted using the supernate to dip the sponges*
- *heat exchangers. The first was a large metal farm tan. The next was a large porcelain tub with ice cold water used to lower the patient's temperature, then into the OR and onto the OR table, cooling blankets over and under the patient. This system was used when I first arrived. The third was a clear polycarbonate tank that would hold a helix coil 4-feet high and 4 feet in diameter.*
- *helix coil stopper—a black rubber Erlenmeyer flask plug with one outflow hole, later replaced by o-rings*
- *arterial filters—shaped just like a Fram oil filter for automobiles. I spoke with the engineer and asked if he had copied the Fram design, and he said yes.*
- *Avalon sponge—used to block holes in the heart, in various shapes, then placed in stainless steel molds to make the required shape and sterilized in the autoclave*
- *Brown-Harrison radiator hose clamps—largest radiator manufacturer for GM (General Motors), automobile radiator hose clamps; used on helix coil, heat exchanger*

THE FIRST TO HAVE A BUILT-IN HEAT EXCHANGER: TEMPTROL OXYGENATOR

This was a polycarbonate shell that leaked—I had to use bone wax in the lab to stop leaks. The metal can was a large juice can, which, when opened, revealed a bunch of ping-pong balls inside, which were soon changed to flow baffles. I took the first one to display at the Minnesota AmSECT Meeting #4.

OXYGENATORS

All oxygenators have had some problems.

- *cross-circulation (child and parent): pump could go too fast or too slow*
- *Gibbon screen: air and defoaming problems*
- *DeWall bubble, University of Minnesota.: pump housing split tubing*
- *DeWall, University of Minnesota/Travenol: poor heat exchanger, splits in plastic housing*
- *DeWall-Bentley: early ones leaked like a sieve, used bone wax to stop leaks*
- *Landy-Edwards membrane (we called it "The Battery"): dead spots that caused clots*
- *Travenol membrane, Ron Lenord: best of that era, dead-end flow patterns, we could change the membrane during bypass within 1 to 2 minutes with pumps on*

- *experimental General Mills, four-ply Galen OptiFlo: bubble oxygenator, good oxygenator, leaks and poor heat exchanger, problems in manufacturing, one-way air release put in backwards, caused big blowups*
- *William Harvey Research bubble: very good oxygenator, problems with laser-cut holes for gas and oxygen*

Over the years, we made many changes, but only one at a time, and we tested them in the lab. We received telephone calls that oxygenators were not performing. To find out what they had changed, we would have them go back to the original configuration. Usually, it was oversized holes in the disperser, or the length of the oxygenator tubing.

PUMPS

- *sigmamotor: sine-wave pump; cost \$500; Van Hungerford trained me on how to repair it. Van had been a submarine commander. The pump had two heads and was very noisy. If the electric power went out, we had orderlies operate the cranks until the power was back on.*
- *Med Science, St. Louis, Missouri. The worst I had to use in Chicago. The electronics were not reliable, and the pump housing had to have the tubing locked in. If you had a tubing failure, you would have to swap out to another head.*
- *Pimpco, Cleveland, Kay-Cross. It was reliable; however, it was at least 5 feet high.*
- *Sarns, Ann Arbor, Michigan. Dick Sarns; the best pumps and consoles*
- *Stockert. Well made, but expensive*

AmSECT

AmSECT was founded to include, not exclude, and to improve our members as perfusionists, hold yearly meetings and regional meetings, to create and supply a journal to expand the knowledge and technology of perfusion. A Mayo Clinic M.D. accused me of starting a union. I responded that we needed to emulate your great surgeons' lead to improve our members. Their pump techs were not allowed to attend AmSECT meetings. We made sure their techs knew when and where our meetings would be held. I set up regions and asked for volunteers, and some I appointed. Next were bylaws, voting for various officers, and society incorporation.

I asked Dr. Lillehei if I could peruse his medical library and if he had any texts pertaining to pumps or articles on this new heart-lung equipment. When he said yes, I went to his office right away. There wasn't much there. However, there were a lot of cardiovascular meetings to attend. I went to a meeting at a big hotel in Minneapolis and

decided that this was the format we needed for training perfusionists. I told Jim Wade that was what we needed. Jim and I got sidetracked with our regular job responsibilities, and nothing was accomplished at that time.

I moved to Chicago with Dr. DeWall, and I told him of my concerns about the need for a medical society for pump techs. He said, "Go ahead," so I told him I had to ask Jim Wade if he wanted to found the society. Jim said he was too busy. Dr. DeWall was very helpful with: information as to where the surgeons' headquarters were in Chicago; using his telephone; his secretary's time, and a typewriter for my wife to type letters to hospitals performing open-heart surgery procedures, with attention to their pump techs to respond and also to let me know of any others to contact. Then, I assigned regions; those regions remained the same until very recently.

After receiving many letters, I responded by telephone and return letters, inviting my respondents to meet in Chicago, at Mt. Sinai Hospital, for the first meeting of AmSECT. Dr. DeWall spoke, and the hospital provided food and sodas. We all agreed that we must go forward. I asked who would take which region and call others to the next meeting. We agreed that Chicago was centrally located, and more people could get there easily. I told the attendees if they could not manage, to let me know. I frequently had to replace volunteers because they were too busy to follow through with their assignments. That fall, we had more interested techs. The next meeting was set for Cleveland, Ohio at the Cleveland Clinic. We also decided not to form an international society because the name would then be "InSECT." The next meeting was in Minneapolis, where I presented the first oxygenator with a built-in heat exchanger, which was also disposable.

Dr. DeWall and I were very busy with many projects. I was the manager of all our labs and personnel. We did our payback to Dr. Wangenstein and his gastric freezing for bleeding ulcers. The cooler was a SwedenFreeze ice cream machine we adapted to almost freeze alcohol through tubing and a pouch shaped like a human stomach. Two brothers from Indiana had eaten too much spicy chili and beer. After their surgeries, they went home happy and were told not to drink beer or eat spicy chili. Later, on the front page of the Chicago newspaper, there was a color photograph of the two of them with their chins over a big pot of chili. (So much for following their doctor's orders!) We also had a priest come in for the freezing, then he started singing and we had to ask the Mother Superior to leave because his singing became very bawdy. When I started warming and deflating the balloon, we found a pinhole in the balloon; which explains why the priest was a very happy patient.