A Tribute to Willem Johan Kolff, M.D., 1912–2009

Lee W. Henderson
Sorbent Therapeutics, Inc., South Kent, Connecticut

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Willem J. Kolff, M.D., 97, inventor of the first artificial organ to reliably sustain life, died of congestive heart failure on February 11, 2009, in Newtown Square, PA. Dr. Kolff is widely considered the "father of artificial organs." His rotating drum artificial kidney was initially reported in 1943 and, for the first time, offered an effective intervention for the treatment of acute renal failure.[1] It was in The Netherlands during World War II at the height of German occupation that he began work on the first dialysis machine. He had moved to a small hospital in Kampen, on the Zuider Zee, to escape the Nazi sympathizers who had been put in charge of his hospital at Groningen. There, conducting bench experiments with sausage casing (Visking Casing Corporation), saline, and urea, he saw that urea moved down its concentration gradient and equilibrated across this cellulosic membrane. He then cobbled together his rotating drum artificial kidney from miscellaneous available parts including bed slats, a bathtub, and sundry tubing connectors of considerable sophistication. It is the only artificial kidney where uremic blood is circulated through tubing that itself is moving through a stationary noncirculating dialysis bath. The membrane area employed was 2 to 2.5 square meters, depending on the spacing of the spiral windings of the cellulosic tubing around the drum. Priming the blood path required 1.5–2.0 units of blood from the blood bank. There was no formal blood pump—the rotation of the drum along with gravity moved the blood out of the patient and then back. As such, achievement of ultrafiltration required high concentrations of bath glucose, analogous to peritoneal dialysis. Only the lower 25% of the rotating drum was immersed in the dialysis fluid that resided in the underlying bathtub.

Although others had explored intellectually and in bench experiments,[2,3] the concept of using a semipermeable membrane to remove uremic toxins, it was Kolff who reduced these observations to clinical practice.

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Correspondence: Dr. Lee W. Henderson, Sorbent Therapeutics, Inc., 56 Spooner Hill Road, South Kent, CT 06785. Phone: 860-927-0192; Fax: 860-927-3511; E-mail: hndrsnlee@aol.com

Pim, as his friends and family referred to him, was a man of his hands. This may have been the result of his early dyslexia, a condition unrecognized at the time, and his father, a physician who arranged for him to have classes with a local carpenter on the weekends after his schoolwork was complete.

To my awareness, no animal experimentation was ever undertaken with the rotating drum artificial kidney, and the first 15 people treated for kidney failure died. Further work on blood anticoagulation and improvement of the blood path of the device resulted in a success on the 16th patient. She was a 65-year-old Nazi sympathizer by the name of Maria Schafstad. As the story goes, Mrs. Schafstad regained consciousness on treatment and declared, "I'm going to divorce my husband" (he was not a sympathizer). She did just that and lived for another 6 years before dying of a cause unrelated to kidney disease.

Pim's perspicacity in the face of serial deaths speaks to his intense personal conviction that what he was doing was important. I think of a meeting of the American Society for Artificial Internal Organs (ASAIO) where much of his work was presented. Pim was asked to chair a session to which he had submitted an abstract that had been reviewed and turned down. He accepted and summarily limited the scheduled 5-minute postpresentation question and answer period to one question for each of the participating speakers. With the last paper concluded, Pim announced, "The session has finished early, and I wonder if Dr. F. would care to make a few comments." Needless to say, Dr. F. went to a floor microphone and delivered the Kolff paper, replete with a complete set of slides and a full 10 minutes of questions and answers.

With the recovery of Maria Schafstad, the era of dialysis for the treatment of acute renal failure commenced. Although the complexity of his initial device rendered the therapy a significant challenge for the treating physician, it swiftly spawned the development of simpler and more elegant equipment. In essence, this was an example of the "statistics of one," that is, a single observation that triggered the development of an entire field of therapy for both acute and chronic renal failure without a formal interventional study showing a statistically significant improvement in survival over a randomly selected control group.

Kolff came to America in 1950, bringing with him one of his artificial kidneys. Physicians at both Mount Sinai Hospital in Manhattan and the Peter Bent Brigham Hospital in Boston worked with the device both as a prototype and in subsequent industrial upgrades.

Dr. Kolff's research into artificial organs did not stop with the kidney. Shortly after arriving in the United States, he joined the Cleveland Clinic, where he began work on an artificial lung, or membrane oxygenator—many functional

analogies exist between the rotating drum artificial kidney and this artificial lung. Then, in 1967, he moved to the University of Utah as chair of the Institute for Biomedical Engineering. It was here that he and Robert Jarvik, his fellow, developed an artificial heart, the Jarvik-7, which was placed in the now famous patient Barney Clark. Also at the Kolff laboratories in Utah, he conducted research with Dr. William Dobell on an artificial eye that would physically tap into the normal visual cortex of a blind subject with damaged retinae.

Pim remained active in research his entire life. Although he formally retired in 1986, he continued working in the laboratory at the University of Utah until 1997. In 1994, he received the John P. Peters Award from the American Society of Nephrology, and in 2002, at age 90, Kolff received the Albert Lasker Award for Clinical Medical Research for his work on the artificial kidney.

Willem J. Kolff, M.D., will be remembered worldwide as a tireless contributor to the advancement of biomedical engineering. Millions of people are alive today because of his seminal work on the artificial kidney. Four sons and a daughter survive him.

DISCLOSURES

None.

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