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*In memoriam*

# In Memoriam Willem Johan Kolff – the Father of Artificial Organs

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***"If men knows the structure of his body, he should be able to build it"*** this was the credo of the life of Willem (Pim) Johann Kolff, one of the most influential and creative medical scientist of our century, rightly called the "Father of Artificial Organs".

***Pim Kolff*** was born on February 14th, 1911 in Leiden, the Netherlands and passed away on February 11th, 2009, in Newton Square, Pennsylvania/USA, just three days before achieving his 98th birthday.
When Professor Dr. Kolff reflected about his youth he stated: "I didn't want to be a doctor when I was a boy, because I didn't think that I could bear to watch people die, and I'm not so sure that I'm resigned to it yet".
To fight death means to fight the impossible and unavoidable. During his entire life, Pim Kolff has challenged such scholastic assumptions by repeatedly turning the impossible into reality.
In the following we would like to shortly summarize his main achievements in the area of artificial organs:

### *Artificial Kidney*

In October 1938, a patient named Jan Bruning, died from end-stage renal failure at the University Hospital in Groningen. The young doctor Willem Kolff saw him dying and started to search the literature for methods to remove urea and other uremic toxins. He traced the first attempts on the artificial kidney, published by Georg Haas in Germany, Abel *et al*. in the USA and Heinrich Necheles in China.
In Groningen, Kolff started his first experiments on blood purification with Cellophan tubes and Heparin as an anticoagulant with the support of Robert Brinkmann, a professor of medical biochemistry.
Following the Nazi occupation of the Netherlands and his active sympathy with the Dutch resistance organization he had to leave Groningen for the City of Kampen in 1940, where he pursued his experiments on the artificial kidney. Fortunately, he got in contact with Hendrik Berk, an engineer and director of a local company, who advised him to wind the Cellophan tube around a horizontally arranged drum. This did mean that the blood would have to flow from a stationary into a rotating Cellophan tube and the Rotating Drum Artificial Kidney was born.
On March 17th, 1943 he performed his first hemodialysis, lasting 20 minutes. Subsequently 15 patients were treated before Sophia Schafstad became his first patient, suffering from renal failure "where you can honestly say, she would have died had she not been treated with dialysis" (Kolff).
Following this successful treatment, Dr. Kolff aimed to make that therapy elsewhere available. The rotating drum, then, was successfully used outside the Netherlands in the USA and in the United Kingdom.
After the War, Pim Kolff followed an invitation to the USA in 1950, where he continued his work on the improvement of the artificial kidney. His target always was to develop simple, reliable and cheap dialysis devices, which should be available to everybody, who needs it.
During this period of experimental development at the Cleveland Clinic, he even used commercially available washing machines and succeeded finally in creating together with Bruno Watschinger from Austria the first Coil Kidney, which later became one of the most successful commercially available dialyser.
In 1967, Dr. Kolff moved to the University of Utah, where he created the worldwide first complete Institute for Artficial Organs, which he named "Institute of Biomedical Engineering" in anticipation of future development.
Together with the one of the authors (H.K.) he worked on the development of a dialyser device, which could be reused indefinitely by replacing the membrane only in a easy to built hardware support, called Easy-S - Kidney, using – most likely for the first time - an ultrathin membrane with a high ultrafiltration rate.
The final goal was to make dialysis not only available to everybody in need but also to provide freedom of movement for the patients may it be at home or abroad. This resulted in the introduction of a wearable artificial kidney into clinical use and its clinical application during holiday-dialysis in the deserts of Utah.

### *Artificial Lung*

After observing already in Groningen that blood, which initially was dark red turned to light red after the passage through his dialysis cellophane tubes, he anticipa-

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ted, that such a device could be the basis for a heart-lung-machine and performed animal experiments in Kampen.
During his time in Cleveland he continued with these experiments, which resulted 1957 in the first membrane oxygenator to be clinically applied successfully.
Later Dr. Kolff reported: "When I came to Cleveland I brought three excellent heart - lung machines, but nobody in the United States was interested. I had to wait five years before the heart surgeons began to realize that they could not do all surgery blindly".

***Artificial Heart***
With the excellent facilities available in Salt Lake City Dr. Kolffs interest centered more and more arround cardiac assist devices and the total artificial heart, with Drs. Kwan-Gett, Jarvik and Olsen becoming his co-workers.
In 1981, a calf survived for more than 260 days with the Kolff artificial heart, giving rise to apply to the FDA for clinical application.
On December 2nd, 1982 Dr. Barney Clark was the first patient to receive an artificial heart invented and fabricated by Dr. Kolff and implanted by Dr. William DeVries at the University of Utah Medical Center.
Since it was always the gracious gesture of Dr. Kolff to put the name of his co-workers on his original inventions, this artificial heart device became later commonly known as the Jarvik-Heart.

***Other Artificial Organs:***
According to his believe, cited in the beginning of this Memorial, Dr. Kolff gathered around him scientists from all over the world, sharing his drive for the impossible.
Under the direction of Dr. Bill Dobelle he started a much discussed Artificial Eye Program by using a minituar TV- device as transmitter and the implantation of electronic chips in the brain as receiver.
Blind veterans from the Vietnam-war volunteered for these historical experiments.
Despite the successful transmission of light- sensations, the experiments had to be discarded because of the risk of infection to the brain by the transmitting wire.
The Artificial Arm-Prothesis, developed in Kolff's Institute, was one of the first devices worldwide to make use of neuronal stimulation and became a great success in clinical application.
Computer simulation of organ function, development of biocompatible materials, initially experiments for an artificial pancreas were the content of further scientific activities under the guidance of Dr. Kolff.
His Institute became the Mekka for Medical and Natural Scientists as well as Engineers, working in the new field of organ replacement.
The legendary "morning conferences" were a unique brain storming, chaired with iron discipline by Pim Kolff, even cutting off merciless high ranked international guests if the draw over their allotted time.
Dr. Kolff also used his publicity to organize the international cooperation between the medical and engineering profession in this new field of life saving medical technology.
Together with Professors Atzumi, (Japan) Nose (USA) Funck-Brentano (France) and Klinkmann (Germany) he founded the first International Society for Artificial Organs (ISAO) and was instrumental in the creation of the leading journal "Artificial Organs".
In the political arena, he used his international public standing to fight for peace, understanding and freedom of cooperation among the different political systems. At the end of his presentations he always opted against nuclear wars and political restrictions.
As his personal contributions he used a sabbatical-year in 1975 to work for one year combined in Munich/West Germany and behind the iron curtain in Rostock/East Germany as a Visiting Professor and helped to establish an artificial organs program in Eastern Europe.
As an honour for his life - time achievements, Dr. Kolff received 13 Honorary Doctoral Degrees, 125 prizes and decorations, among them the highly prestigious Japan Award in 1986 and the National Award of Engineering in the United States in 2003.
In 1990, Life Magazine listed him among the 100 most important Americans of the 20th century. In the "Liste De Grootse Nederlander" he ranked 47.
The laudatio for the National Engineering Award, published in March 2003 in "Science" stated: "Today, thanks to Dr. Willem Kolff and his artificial organs, more than a million patients around the world go on living longer, fuller lives. Dr. Kolff will save 1.2 million lives before bedtime".
This number has certainly multiplied since then and will continue to do so.
Dr. Willem Johan Kolff's unconventional thinking to fight against the Impossible, his engineering skills, combined with a precise understanding of physiological parameters and clinical application, make him one of the heroes in medical history.