



In memoriam: Professor Abraham Rudolph (1924– April 9, 2023) - a tribute

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Dr Abraham Rudolph, one of the foremost leaders in Pediatric Cardiology, passed away on April 9, 2023, aged 99. His entire career was marked by imagination, creativity, and a devotion to the care of children with heart disease. He will be sorely missed by the many who knew him personally and the countless physicians whose understanding of their specialty was enhanced by his discoveries and teachings.

Dr Abraham Rudolph, one of the foremost leaders in Pediatric Cardiology, passed away on April 9, 2023, aged 99. His entire career was marked by imagination, creativity, and a devotion to the care of children with heart disease.

Dr Rudolph (Fig. 1) was born in 1924 in South Africa and earned his medical degree at the University of the Witwatersrand, Johannesburg, where he graduated summa cum laude, winning most of the prizes awarded to medical students. After receiving his MB, BCh degree in 1946, he completed his residency at the Transvaal Memorial Hospital for Children, having decided to specialise in paediatrics.

After a brief sojourn in the United Kingdom, during which he passed the examinations for membership of the Royal College of Physicians of London and the Royal College of Physicians of Edinburgh, he returned to South Africa, continuing to work as a paediatrician. At that time, he wrote a thesis on haemophilia that earned him an MD degree.

After a great deal of correspondence, he accepted a position with Dr Alexander Nadas of the Boston Children's Hospital and emigrated with his family to the United States in 1951. Dr Nadas had just started a paediatric cardiology department at Harvard and appointed Dr Rudolph, who soon became head of the nascent paediatric cardiac catheterisation laboratory.

He set up an experimental animal laboratory, working on measuring cardiac output and trying to develop a chronic in-utero animal model. After struggling to find catheters that did not clot, he found a suitable silastic catheter that allowed the development of a chronically instrumented fetal preparation in sheep. The trajectory of his research was set.

During his first few years in Boston, Dr Rudolph participated in several important clinical studies, now classics in the field. The studies focused on common congenital heart lesions such as pulmonic stenosis, atrial septal defect, aortic stenosis, patent ductus arteriosus, tetralogy of Fallot, transposition of the great arteries, and the use of digitalis in infants and children. With his colleague, Dr Julien Hoffman, he studied the natural history of ventricular septal defects and complete atrioventricular block. His many published articles laid the groundwork for our present understanding of these lesions.

While in Boston his collaboration with the physiologist, Dr Clifford Barger, resulted in several important publications on fluid retention and congestive heart failure. He also worked closely with Dr Clement Smith, head of the neonatal service at the Boston Lying-In Hospital on the issue of high mortality rates in premature infants with respiratory distress syndrome. He was the first to perform cardiac catheterisation on these tiny infants, the procedure being very controversial at the time.

In 1961, Dr Rudolph was appointed the chief of Cardiology at Albert Einstein College of Medicine in New York City, where he continued his clinical and experimental work on sheep fetuses in a chronic model. Drs. Rudolph and Hoffman pioneered the use of radioactive microspheres that embolised into end organs. They recognised that the radiation counts of the microspheres could be used to measure regional blood flow and, by computation, systemic and pulmonary blood flow. Using many different isotopes enabled Dr Rudolph and his team to manipulate the circulation of sheep fetuses under many different treatments, which set up an entirely new field of physiological investigation. In New York, he collaborated with Drs. Michael Heymann and Julien Hoffman, leading to many published studies on systemic and pulmonary vascular beds, their reactivity, and the rapid adjustments at birth.

In 1966, Drs. Rudolph, Hoffman, and Heymann moved to the University of California, San Francisco, where they joined the Department of Pediatrics under the chairmanship of Dr Melvin M. Grumbach, and the Cardiovascular Research Institute, then under the inspired guidance of Dr Julius H. Comroe, Jr.

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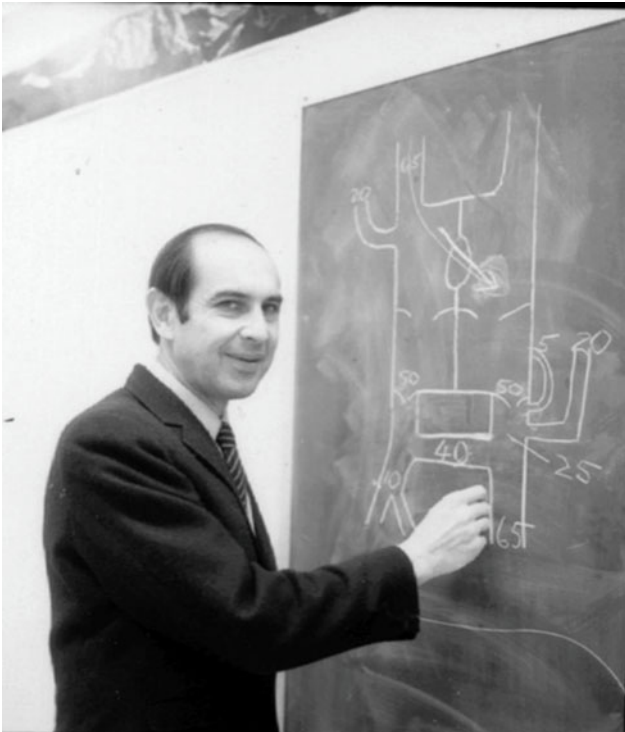


Figure 1. Professor Abraham Rudolph (1924 – April 9, 2023).

In San Francisco, Drs. Rudolph and Heymann completed the first studies of cardiac output and organ blood flow in undisturbed, healthy, conscious fetal sheep, and newborn lambs. This was a major advance in the cardiovascular evaluation of the chronically instrumented animal and has remained, with variations, one of the most commonly used methods for measuring total and regional blood flow.

Dr Rudolph's interest in fetal development and response to stress led to collaborations with obstetricians, perinatologists, and pharmacologists, who worked together to study the fetal and uteroplacental circulations and their responses to a variety of stresses. Many of the insights derived from these studies have been applied to the stressed human fetus.

Dr Rudolph was an outstanding instructor in clinical medicine, cardiac catheterisation, and animal research. His manual dexterity was remarkable. He taught by example, often seen in the animal laboratory cleaning the animal pens and research areas, an exemplar of doing the work oneself rather than delegating it. He trained well over 200 cardiology fellows as well as many animal physiologists, obstetricians and gynaecologists, neonatologists, pulmonologists, and gastroenterologists.

In 1974, Dr Rudolph's synthesis of clinical and physiological concepts in fetal and newborn development led to his unique masterwork, *Congenital Diseases of the Heart: Clinical-Physiologic Considerations*, unofficially re-titled by his fellows 'The Little Red Book of Chairman Abe'. The book was subsequently revised in 2001 and 2009 and remains a cherished primer on CHD.

Yet, even with all the time he devoted to clinical work and research, Dr Rudolph still had time for service to the science community, including stints on the Cardiovascular Study Section and the National Advisory Heart Council of the National Institutes of Health, membership in the Society for Pediatric Research, membership and presidency of the American Pediatric Society, chairman of the Section on Cardiology at the American Academy

of Pediatrics, membership of the research and publications committees of the American Heart Association, and membership on the editorial boards of several prominent scientific publications.

He served on several city and state commissions concerned with cardiac care of the child with CHD. He was an active and much sought-after teacher and lecturer locally, nationally, and internationally. Not the least of his contributions to teaching were his stint as chairman of the Department of Pediatrics at the University of California, San Francisco, and his editorship of the highly successful general paediatric text 'Rudolph's Pediatrics' as well as the companion 'Rudolph's Fundamentals of Pediatrics'.

Dr Rudolph published prodigiously, including over 300 manuscripts in peer-reviewed journals, nearly 100 invited contributions, book chapters or conference reports, and 10 written or edited books. He received many honours, including the E. Mead Johnson and Borden Awards for Research in Pediatrics, the Research Achievement Award of the American Heart Association, the Lifetime Achievement Award of the American Academy of Pediatrics, the Joseph St Geme Leadership Award of the Federation of Pediatric Societies, the Howland Award of the American Pediatric Society, the Arvo Yllpo Award in Helsinki, Finland, and the Jonxis Medal in Groningen, Holland.

He was a member of the Institute of Medicine of the National Academy of Sciences and a former President of the American Pediatric Society. In 1996, he received the

Dokteur Honoris Causa Degree from the Rene Descartes University at the Sorbonne in Paris. In 1999, he received the Nils Rosen von Rosenstein Award from Uppsala University, Sweden. In 2000, he was elected a Fellow of the American Association for the Advancement of Science.

Throughout his career and for most of his life, Dr Rudolph was aided and supported by his wife, Rhona, also a physician of stature, who died in 2006. Abe and Rhona shared many interests outside of medicine. Supporters of the arts, they regularly attended the symphony, ballet, and theatre, and were avid collectors of Inuit painting and sculpture.

Both were ardent readers and adventurous travellers who saw much of the world.

His final trip, taken a few months before his death, was a safari in one of his favourite places – Zambia.

He travelled with his children, Linda, Jeffrey, and Colin, and with numerous grandchildren, all of whom mourn his passing.

The family had a second home in Sonoma County, California, a stone's throw away from some of the finest California wineries, whose products Rhona and he both enjoyed. In addition, Abe was a passionate gardener whose tended rose bushes were spectacular.

He will be sorely missed by the many who knew him personally and the countless physicians whose understanding of their specialty was enhanced by his discoveries and teachings.

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Ethical standard. The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national guidelines on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008.