Richard J. Bing, MD (1909–2010)

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A recent paper describing fuel utilization in the normal and diseased human heart prompted me to revisit the work of Bing. Bing, who died in 2010, would have enjoyed the article. In the late 1940s, Bing was the first to enter the coronary sinus with a catheter [1], to sample venous blood leaving the heart, and to determine both coronary flow and substrate utilization by the human heart [2].

Richard Bing was a trailblazer in the new era of catheter-based cardiology in the years immediately following WWII. His name is synonymous with the hemodynamic profiling of congenital heart disease, with the profiling of the nutrition for the human heart, and with the assessment of coronary blood flow with a radioactive tracer. His devotion to the physiology of the heart was paralleled by his love for performing and composing music. Bing made his mark in both music and medicine, but he shone in cardiology. Later in his long life, he also became the author of several books of short stories. In short, his colleagues called Richard Bing, a renaissance man.

Richard Bing was born in the first decade of the last century in the Bavarian city of Nuremberg. His father was a hops merchant, and his mother sang professionally and performed church music. He also had an older sister. Richard studied both music and medicine in parallel at Frankfurt and graduated from medical school at Munich, in 1934. Thereafter, he left Germany for a brief stay in Switzerland where he obtained a second medical degree at the University of Berne. Subsequently, his fascination

Richard J. Bing, pictured in 1970, explains the operation of a medical device used to determine the quality of blood flow in the heart. Photo/Credit: USC Libraries – USC University Archives.

with cell and tissue cultures, a brand-new experimental technique at the time, led him to the Carlsberg Institute in Copenhagen. Richard had hardly settled into his life's new path when he encountered two visitors from the Rockefeller Institute in New York, the surgeon Alexis Carell (Nobel Prize in 1931), and the aviator Charles

Lindbergh (crossing the Atlantic in 1927). This odd couple had joined forces to engineer tools for organ preservation and organ replacement. It is hard to make out in hindsight, whether Richard seized the opportunity to join the lab, or whether the lab had seized him. In any case, Richard moved to the Rockefeller Institute in 1936 and learned how to perfuse organs. His first paper was a single-author paper in *Science*, written and published at the age of 29 [3]. At the other end of his life's spectrum, Richard published his last original first-author paper at the age of 92 [4]. With 63 years of uninterrupted research productivity (and 71 years of publishing papers), he rivals the Venerable Dr. Routh, who was President of Magdalen College in Oxford from 1791 to 1854.

Back to Bing's career. After his military service with US Army, Richard was hired in 1945 by the surgeon Alfred Blalock to establish a cardiac catheterization laboratory at Hopkins. The need arose from the surgical treatment of cyanotic "Blue Babies" by the shunt procedure developed by Blalock and Helen Taussig. At the time Bing started cardiac catheterization at Johns Hopkins University in 1945, Helen Taussig relied on physical examination, the electrocardiogram, and fluoroscopy for the diagnosis of congenital heart disease. There existed only 2 cardiac catheterization laboratories: one of them directed by the pioneers Andre Counard and Dickinson Richards at Bellevue Hospital in New York; the other directed by Lewis Dexter at the Peter Bent Brigham Hospital in Boston. In the period of 5 years, Bing delineated, in rapid succession, the hemodynamic features of 20 different forms of congenital heart disease, from the tetralogy of Fallot to the Taussig-Bing anomaly, a form of complete transposition of the great arteries [5]. "The chips always came down in the operating room where Blalock had to have a diagnosis". At the time, the tetralogy of Fallot, patent ductus arteriosus, and coarctation of the aorta were the only operable malformations of the heart and great vessels. An incorrect diagnosis before surgery invariably had disastrous consequences!

In 1947, Bing accidentally entered the coronary sinus during a right heart catheterization when he aspirated blood which was pitch black [6]. Bing recognized the importance of his observation. He first measured arteriovenous differences for O_2 , then coronary flow, and changes in substrate concentrations in the blood as it entered and left the heart. Although analytical methods were cumbersome at the time, a new branch on the tree of cardiovascular physiology began to sprout. In a series of articles, reviewed by him in the 1954–1955 Harvey Lecture [1], Bing and his coworkers established that the human heart

extracts almost all O_2 delivered on the arterial side, that an increase in O_2 supply to support greater contractility of the heart can only be achieved through an increase in coronary blood flow, and that human heart muscle is able to meet its energy needs through the oxidation of a variety of substrates mainly fatty acids, but it nourishes itself also with glucose, lactate, ketone bodies, and amino acids as additional substrates. In his work, he characterized the conditions that determine substrate preferences and disease states such as the failing heart, the ischemic heart, and the heart in diabetes.

In 1969 Bing collaborated with George Clark, a physicist at the Massachusetts Institute of Technology, on a new method to measure coronary blood flow in vivo by a radioactive tracer method. On Clark's advice, he used the positron emitter ^{84}Rb and coincidence counting [2]. Although Bing only sporadically followed up on this fundamental observation, others did. In other words, Bing took the first step in what became positron emission tomography of the heart, now widely used for the noninvasive assessment of regional myocardial blood flow and metabolism. As in many of his endeavors, Richard was able to see beyond the horizon.

As already mentioned, Bing lived a long and productive life in research. Some of his critics have said that he dabbled in too many fields of research. Dabble he did, but in the fields he chose to dabble, he was way ahead of his time – from myocardial protein turnover to the structure of contractile proteins, from NO signaling to ion pumps and calcium metabolism.

In 1970, Richard Bing drew the field of molecular and cellular cardiology on the map when he founded (together with Lionel Opie), the *Journal of Molecular and Cellular Cardiology*. Perhaps the most prominent member of the editorial board was Professor Hans Krebs from Oxford. I first met Richard in 1974 at a conference in Quebec, Canada. His structure as a tall man with long white hair stood out among the small group of youthful attendees. During the day, he would chair our sessions, in the evening he entertained us by playing the piano on the stage which created an amazing atmosphere.

Richard Bing's great creativity spanned from medicine to music and ultimately to writing. Although the whole process of creativity still eludes human understanding, it has proved practical to distinguish between 2 kinds of creativity. On the one hand, there is the inspired work of a genius (e.g., Beethoven); on the other hand, there is the precision in problem-solving (e.g., Einstein). Usually, the boundaries between inspiration and tight logic are quite clear, but on occasion, distinctions between these bound-

aries become blurred. Not surprisingly, Richard embraced American culture, especially after his marriage to Mary Whipple in 1938. Together, they raised 4 children. Yet, three of his closest friends were distinctly rooted in European culture. Those were the art historian Sir Ernst Gombrich (*The Story of Art*), the composer Carl Orff (*Carmina Burana*), and the physicist-turned-biologist Max Delbrück (Nobel Prize 1969 for the discovery of bacteriophages).

In academic cardiology, we are fortunate to meet personalities like Richard Bing – controversial at times, but courteous in their manners. Those of us who knew Richard, cherished his strong and colorful language. He liked to joke “It’s easier for me to get a scientific manuscript published in a journal than to get a piece of my music performed in a concert hall.” Bing’s advice for us today? He gave his last collection of prose and poetry, the title “*Para Fuera – Out with It*”, or “get rid of the clutter”. Like Goethe, whose last words allegedly were “*More Light!*”.

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Main Discoveries

- Diagnosis of congenital heart disease by cardiac catheterization.
- Fuel utilization by the human heart.
- Myocardial blood flow measurements with a radioactive tracer.