HISTORY OF ELECTROCARDIOLOGY

Mauricio Rosenbaum: The Internationally Renowned Electrocardiologist South of the Equator (1921–2003)

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Mauricio Bernardo Rosenbaum (Fig. 1), cardiologist, electrocardiologist, teacher, researcher, and mentor to many, was born in Carlos Casares, a small town in the Province of Buenos Aires, on August 25, 1921, and earned his medical degree and doctorate from the school of Medicine of Córdoba University, Argentina. He completed his cardiology training at the Pavilion of Cardiology Luis H. Inchauspe of the Ramos Mejía Public Health Hospital under the direction of Professor Blas Moia.

After a short stay as chairman of Cardiology of the Salaberry Hospital, Dr. Rosenbaum worked there as head of the Cardiology Division of the Ramos Mejía Hospital from 1973 until his retirement in 1986. Mauricio left Argentina first in 1954, when he was appointed Research Associate in Vermont by Eugene Lepeschkin and Wilhelm Raab. He returned to the United States in 1969, when he was invited as Visiting Professor of Cardiology at the University of Kentucky, to replace Dr. Boris Surawicz during his sabbatical year in Switzerland.

Scientific Contributions

In Buenos Aires between 1952–1960 Mauricio's main research interest became Chagas' disease and Chagas' myocarditis, and he published 15 papers on the clinical and epidemiological aspects of this disorder. Chagas' disease was of paramount importance in Argentina, and in fact, the alarm launched by Mauricio, provided the turning point in the development of health campaigns in Latin America to control the disease.

Figure 1. Dr. Mauricio Rosenbaum (1921–2003) during one of his lectures.

In the early 1950s, Rosenbaum saw a patient with an anterior myocardial infarction who had an ECG showing right bundle branch block (RBBB) and left axis deviation (QRS axis -75°). A few weeks later, the QRS axis shifted to the right at $+110^\circ$ in the presence of the RBBB. In other tracings, the left and right QRS axes alternated with each other. Since RBBB was constant, it was reasoned that the changes in axis occurred because the impulse could follow two different pathways within the left ventricle. This was the starting point of the whole trifascicular concept of intraventricular conduction. In 1955, Rosenbaum published with Dr. Lepeschkin a paper on "Bilateral Bundle Branch Block",¹ which is a classic in the field. In the same year they published their paper on "The Effect of Ventricular Systole on Auricular Rhythm

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in Auriculoventricular Block,"² another classic frequently cited in the literature. In 1968 Rosenbaum and coworkers published the results of a series of investigations, which were initiated by Rosenbaum in the 1950s, in a book entitled *Los Hemibloqueos*.³ This book had a marked impact on Latin Cardiology, which extended to the international scientific community after the publication of a shortened English version in 1970.⁴

The publication of *The Hemiblocks* coincided with two outstanding technical advances in Cardiology. One, the recording in humans of the His bundle electrogram, due to the studies by Benjamin Scherlag. The other, the development of artificial pacemakers that resulted from research of a great number of clinical researchers and of electronic engineers. The three discoveries were not only contemporary but also complementary and produced a striking advancement in the diagnosis and treatment of the conduction disturbances. A study of the His bundle could not be correctly interpreted without the idea of the trifascicular intraventricular conduction and the decision of a pacemaker implant became dependent and still depends on the diagnostic criteria that were made possible by Rosenbaum et al.'s work. That contribution occupied a central position in interdisciplinary progress in the diagnosis and treatment of many cardiac patients.

Several articles published in international journals between 1968 and 1973 expanded the recognition of the research work that originated in Argentina.⁵⁻¹² The anatomical, physiological, experimental, clinical, and pathological studies, carried out at the Pavilion Luis H. Inchauspe, Ramos Mejía Public Health Hospital in Buenos Aires, marked a breakthrough in the field by showing that there were three and not two ventricular terminals of the conduction system: one in the right and two in the left (the anterior and posterior divisions of the left bundle branch). It was shown that the conduction system that was trifascicular, and a whole family of conduction disturbances were identified that permitted more accurate diagnosis and better treatment of patients with conduction disturbances.

The new trifascicular concept of intraventricular conduction revolutionized the interpretations of the electrocardiograms. The books *Los Hemibloqueos* and *The Hemiblocks* provided new information for the diagnostic and interpretation of a wide variety of theoretical and practical problems related to patient care. It is just worth mentioning that the "new

conduction disorders" (hemiblocks) can mimic or hide a myocardial infarction or also disguise or conceal ventricular hypertrophy. While the theoreticians were not even in agreement with the essence of the new theory and the nomenclature to which it gave origin, cardiologists and clinicians all over the world could recognize in their patients the new signs of disease of the conduction system following the diagnostic criteria established by Rosenbaum and his coworkers.

The studies on the physiology and pathophysiology of intraventricular conduction and the mechanisms of cardiac arrhythmias and also of ventricular repolarization by Rosenbaum and coworkers were published between 1970 and 1990 in important international journals. The group became leaders in fields such as the concept of phase 3 and phase 4 blocks, the paroxysmal AV block, supernormal conduction, Wenckebach block in the bundle branches, electrotonic modulation of parastolic foci—all of them expressing the relationship between automaticity and conduction.¹³⁻²⁴ Among the studies on antiarrhythmic drugs, the introduction by Rosenbaum and colleagues of amiodarone as an antiarrhythmic agent caused it to become one of the major drugs in cardiovascular pharmacology.²⁵⁻²⁹ The description of the electrotonic modulation of the T wave and cardiac memory was of paramount importance.³⁰⁻³¹ The biological and clinical implications of this concept of cardiac memory made these contributions one of the most original additions to the knowledge of the cardiac activity reported in recent years.

From the early 1990s to the last years of his scientific work, Mauricio devoted time and effort to the study of the antibodies to β -adrenergic and M2 cholinergic receptors disclosing agonist-like properties and their potential role in the pathogenesis of atrial and ventricular arrhythmias, idiopathic dilated cardiomyopathy, and chronic Chagas' cardiomyopathy.^{32,33}

International Meetings

In 1970 Mauricio was invited to the landmark Symposium on Cardiac Arrhythmias in Elsinore, Denmark.³⁴ His participation greatly surprised and impacted the qualified audience with the excellence of his three lectures at once clear, distinct, and inspiring.³⁵⁻³⁷ He lectured on the site of origin and the clinical significance of ventricular extrasystoles, presented a plausible explanation

proposed to unravel the mechanism of the so-called narrow ventricular ectopic beats, and made a remarkable contribution to the anatomical bases of AV conduction disturbances and the prognostic significance of the QRS complex, particularly, right bundle branch block with left posterior hemiblock. In Elsinore, Mauricio met among others, Vaughan Williams, Leo Schamroth, Toyomi Sano, Bramah Singh, and several younger-generation electrocardiologists and also learned about beta-blocking drugs, the pharmacodynamic of amiodarone, this new antiarrhythmic drug that started there its odyssey.

Following the Elsinore Conference, Mauricio took part in many conferences throughout the United States and Europe as a master teacher and lecturer, delivering more than 200 lectures. In 1975 H.J.J. Wellens, K.I. Lie and M.J. Janse organized in Amsterdam the workshop on "Conduction System of the Heart."³⁸ That was the forum for the academic presentation of phase 4 block (together with phase 3 block) to explain various old and still unresolved problems of clinical electrocardiography: intermittent phase 3 and phase 4 bundle conduction block; paroxysmal atrioventricular block; some forms of presentation of parasystole, and of the Wolff-Parkinson-White syndrome and the effects of certain drugs upon automaticity and conduction. Interestingly, all these apparently dissimilar problems were aligned together applying the proposed relationship between automaticity and conduction. Rosenbaum delivered the St. Cyres lecture in 1977 at the National Heart Hospital of London, England, where he was the first Latin American Cardiologist to address such a distinguished audience.

In a memorable workshop held in Buenos Aires in 1981, important contributions like the electrotonic modulation of the T wave and the possible existence of "cardiac memory," the mechanism of intraventricular aberrant conduction of supraventricular premature beats, factors influencing bundle branch block, supernormal conduction, etc. were presented and discussed and were reported in the book entitled *Frontiers of Cardiac Electrophysiology* published by Martinus Nijhoff (Leiden, The Netherlands) in 1983.³⁹

In 1989, an International Symposium entitled "20 Years of Evolving Arrhythmia Concepts" was held in Utrecht to honor Mauricio B. Rosenbaum. During this two-day symposium, the so-called "Rosenbaum's babies" occupied the podium and were the center of the scene.

Mauricio thought about research as a risky activity involving different proportions of passion, enthusiasm, and adventurous spirit. Because of his character, his charisma, his talented thinking, and his teaching, he created and maintained around him for many years an atmosphere of permanent exchange and mutual loyalty between master and disciples in "Rosenbaum's school of electrocardiography."

The Humane and Medical Doctor Model

Mauricio was one of those exceptional human beings who was characterized by his intelligence, contributions, and his cultural and moral integrity. Mauricio was primarily a clinical cardiologist, a doctor of patients. The same mind he used so masterly for science and research, he also employed to care for the body and the soul.

He was demanding of himself and established standards of behavior that set the rules for the development of a full generation of Argentinean cardiologists. We valued a paper, a lecture, or even a simple clinical record according to what, in our imagination, Mauricio would say about it. His presence in a scientific meeting was looked forward to by some and his absence noted with relief by others. The size of academic, political, or historical personalities in cardiology in our country is measured by comparison with his values. In every aspect of our lives, he guided us what was important and away from the charlatan or the fraud. Those who had the chance to look at most of the fairly good cardiologists in our country, would not have been surprised to find Mauricio's fingerprint on some of them. Another aspect of Mauricio's personality, well recognized by all who could know him, is that he was not only a scientist and a cardiologist but also an exceptional human being, humane in the admirable sense of the word. That kind of human model that teaches us the ethics of medicine and life without ever using the word, that helps us set priorities in life just by tenderly marking the difference between valuable and shameful behavior.

He was scrupulously honest, sensitive, and humble when it came to the troubles of the world. As many of us sorted our way into responsibilities of life, there was Mauricio always handy to listen to our bewilderment to share his wisdom and his ignorance with us. Because of his charismatic charm, kindness and wit he always befriended scientists and physicians worldwide and gained their respect

through virtue of his cultural background, his great intellect and his exceedingly productive scientific career.

Mauricio was a very cultivated man. He was an enthusiastic music lover and Mozart and Beethoven were his favorites. As a matter of fact, he himself was a very good pianist to the point that he could have made a career by playing the piano in a tango orchestra. He enjoyed soccer (Boca Juniors' fan) and chess as the main attractions for his light moments. He liked intimate reunions with friends in a relaxed atmosphere, enjoying good wines, Campari and Argentinean specialties, particularly "asado" (barbecue).

Rosenbaum's International Recognition

The importance of Dr. Rosenbaum's school's contributions was rapidly recognized by the international scientific community and became from that moment on firmly established in cardiological literature as a historic milestone.

Mauricio was the recipient of many honors and awards. He was Honorary Fellow of the American College of Cardiology (the first one from Latin America), and honorary member of other cardiological societies. He was Editorial Board Member and Consulting Member of the most prestigious international journals. He received the Distinguished Scientific Award from the North American Society of Pacing and Electrophysiology. The School of Medicine of Buenos Aires University granted him the title of Honorary Professor of Medicine of the Buenos Aires University and the city of Buenos Aires prized him with the title of Illustrious Citizen for his scientific contributions.

In an article published in the American Journal of Cardiology on the occasion of the 10 years of publication of *The Hemiblocks* and under the title "Historical Milestones," Professor Herman Uhley from San Francisco stated: "Perhaps the greatest testimony to their contribution is the large number of related publications by many authors since the printing of *Los Hemibloqueos* more than 10 years ago."⁴⁰

Uhley concludes his article by saying: "The concept of trifascicular conduction has had a major effect on the contemporary practice of cardiology, influencing the work of clinicians, researchers and students. The anatomists began to reinvestigate the details of the atrioventricular and intraventricular conduction system. Pathologists gained re-

newed interest in clinical correlations. Electrophysiologists were stimulated to investigate the electrical activity of these specialized structures under various conditions. Students learned a new unified approach to atrioventricular and intraventricular conduction. Most important, clinicians gained insight into previously unexplained phenomena and were able to apply these new concepts to the daily interpretation of patients' electrocardiograms." Of note, the names Lenegre's and Lev's diseases given by Rosenbaum to the conduction system disorders described by these worldwide known pathologists have been incorporated to the cardiological jargon and formal literature.

Leonard Dreifus stated at the Presidential Citation of the American College of Cardiology in 1975, when Mauricio was appointed Honorary Fellow of the ACC, that "Dr. Rosenbaum and his coworkers' findings represent a fundamental advance in the understanding of intraventricular conduction disturbances. In this respect, the substance of work has stimulated the physiologists, the anatomist and the clinician to redefine principles of the entire AV transmission system." "From this turnabout came some of the most exciting advances in clinical electrocardiography. It is particularly important that these observations were brought into sharp focus when so much confusion had existed in the understanding of conduction disturbances ... Mauricio has been a leader in a new revolution from the South ... in his persuasive way he has stimulated many scientists throughout the world. He has given generously his time, has traveled to different countries on numerous occasions as a master teacher and lecturer and has obliterated the communication gap that could have delayed this new knowledge for many years."

Leo Shamroth from South Africa in the prologue of the monograph by Henry Kulbertus from Liege, Belgium, writes in 1978: "Ten years ago, the elegant studies of Mauricio Rosenbaum and his collaborators revitalized and established the concept of hemiblocks. Their contributions triggered a tremendous interest and stimulated new studies that grew like mushrooms, giving rise to an enormous literature."⁴¹

In the book *The History of Cardiology*, Acierno LJ⁴² stated: "Rosenbaum and coworkers were the prime movers who put together the cumulative experimental and clinical data that led to the creation of a comprehensive concept so that now we think in terms of hemiblocks and trifascicular block." "The

concept acted as a catalyst for further investigations by anatomists, pathologists and electrophysiologists."

Once more, in 1993, the international scientific community and his collaborators reunited to honor Mauricio in the commemoration of the Hemiblocks' silver jubilee in Buenos Aires, Argentina.

Final Remarks

In conclusion, it can be said that almost every study or paper coming from the Argentinean group represented a significant step forward in our understanding of the electrophysiology of the heart and its electrocardiographic counterpart.

Apart from the originality of Dr. Rosenbaum's scientific contributions, there is another reason that increases their value: the extreme simplicity of the technical facilities with which these studies were done from his modest laboratory in Argentina. His production was purely and genuinely Latin American. As pointed out by L. Dreifus in his aforementioned speech: "Rosenbaum accomplished these scientific achievements in the simplest of surroundings. In an era of grantmanship and unparalleled scientific technology in the form of sophisticated electronic recorders and computers, he required very little more than precise observations and careful anatomic models."

Rosenbaum's fine sense of humor was proverbial and exemplified by the following: in a rather informal lecture on the history of electrocardiography, Mauricio said "I pretend though naively, to belong to a most illustrious electrocardiographic family. I refer to Wilson as the father, Einthoven as the grandfather and Sir Thomas Lewis as the rich uncle from abroad."

In 2003 Mauricio left us physically, but he remains with us as the great teacher, the enthusiastic researcher, the loyal friend, the humanist and the caring physician, bequeathing us his moral and ethical example and the great honor of having been his disciples, sharing happiness and sadness for many years.

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