



# Medical Revolution in Argentina

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A diagnostic imaging study is useful when its outcome, either positive or negative, helps to confirm a diagnosis or modify therapeutic behavior.  
— Silvia Moguillansky, MD



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**D**uring the 20th century, medical imaging experienced a phenomenal growth by becoming an essential complement in clinical practice. In the 21st century, it continued to grow with a new and important role in daily practice as well as innovative developments, especially associated with molecular biology. Imaging has a central role in medical education in general and noninvasive therapeutic procedures. To accompany this development, bioengineers and physicists are expected to develop different strategies and build bridges among medical professionals and develop new diagnostic methods to promote optimal application. This growth is associated with a large

## A Brief History of Medical Imaging Research

increase in costs; for emerging countries such as Argentina, access to new technology is complicated; hence, it is essential to rationalize its use.

From prenatal testing to complex issues such as Alzheimer's disease, new scientific and technological advances in imaging take place on a daily basis. The interaction of computers and technology has made imaging to be increasingly necessary, because of the possibility of intervening in the course of disease and even a step before the disease occurs, to provide treatment and perform minimally invasive surgical practices. Medical imaging is important whether you need to diagnose a condition early, plan surgery, or conduct radiation treatments. Imaging has become a pillar for both clinical as well as surgical medicine.

### History of Medical Imaging in Argentina: The Pioneers

In December 1896, just one year after the discovery of radiograph by Wilhem Roentgen, the first radiograph in Argentina was taken by Tomás Varzi, M.D. Later, he founded the Bahía Blanca Hospital (southern Buenos Aires state), where he produced more novel radiographs.

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Dr. Varzi, after residing in Germany for three months and knowing the news of the discovery of X-rays, acquired the equipment through the mediation of a German consul, Diego Meyer. With this equipment, Varzi obtained a hand radiograph by performing the Roentgen method three times, as the anode would nearly melt down after 20 min. Furthermore, he examined the hands and chest of lean subjects with a fluoroscope. Much later in his pioneering career, he summarized his radiographic experience in a paper presented at the first Inter-American Congress of Radiology held in Buenos Aires in 1943.

In July 1893, Jaime R. Costa, M.D., was appointed professor of medical physics at the Faculty of Medicine of Buenos Aires. Awarded with a gold medal upon his graduation, he was devoted to teaching physics, i.e., electricity and its applications. He started teaching radiology in a medical physics course in 1897, and a year later, he carried out the first X-ray examination of hand and foot. Enthusiastically devoted to the study and development of X-rays, Dr. Costa is considered as a precursor of radiology in Argentina.

In 1901, he traveled to Europe to enhance his knowledge of X-ray applications. In 1903, he proposed the foundation of the Institute of Physiotherapy and incorporated an existing service of electrotherapy, and later, updated and enhanced the Hospital de Clínicas in Buenos Aires, where Costa was appointed a headmaster.

Upon Costa's death, he was succeeded by his disciple Alfredo Lanari, who was born in Corrientes province in 1879 and graduated medical school in 1902. Being the chief of laboratory for the physics course and the director of the Institute of Physiotherapy, he was elected twice as dean in 1919 and 1927, respectively, by a unanimous vote of his colleagues and students. Dr. Lanari struggled to introduce radiology into the medical curriculum as an independent subject, even creating the course of radiology that was incorporated into the curriculum of the Medicine School in 1920. Lanari was the second precursor of radiology in Argentina and the founder and first chair professor of radiology and physiotherapy at the School of Medicine of Buenos Aires. He died in Rome in 1930.

Carlos Heuser, M.D., Ph.D., was born in Buenos Aires in 1868. In 1902, he obtained the title of Doctor of Medicine with a gold medal for his thesis titled "Practical Guide of Radiology and Physiotherapy," and he was the first radiology graduate from Argentina. Dr. Heuser was also the first researcher to apply lipiodol to perform a hysterosalpingography. Shortly after in 1922, this contrast agent was discovered by French scientists Sicard and Forestier. Heuser presented his research in a paper at the Latin American Medical Congress in Lima (Peru) in December 1924. His purpose for making such radiographies was the discovery of early pregnancy, and one of his first images was taken to Paris by Prof. Mariano Castex, who introduced Siscard to him in 1925. This meeting was followed by a fruitful cooperation that resulted in more than 50 papers on obstetrics, gynecology, and urology.

Humberto H. Carelli, M.D., Ph.D. (Buenos Aires, 1868–1963), graduated from the School of Medicine of Buenos Aires in 1909. His thesis work was titled "Treatment of Leukemia by Roentgen Rays." He got trained at the school with Dr. Costa, working at the Medical Physics Laboratory from 1901 to 1911 and lecturing as a faculty of medicine and dentistry. He wrote numerous papers and was best known for his publications on pneumoperitoneum in abdominal examinations and, especially, as the creator of perineal emphysema in 1921. This method—known worldwide as Neumorinon—was presented in lectures at universities, congresses, and medical societies in Argentina and abroad. As an accomplished researcher and great man, Carelli founded the Municipal Institute of Radiology, inaugurated in 1931, which was an inspiration of Finsen Institute in Copenhagen. He remained in office until 1938.

Pedro Mirizzi (b. Córdoba, 1893) graduated from medical school in 1916. After a fellowship period, he was appointed a professor of surgical pathology, University of Cordoba, before the age of 30 based on his achievements. As a founder and first president of the Society for Surgery of Cordoba, he was a pioneer in the investigation of bile ducts, achieving international renown. In 1931, he developed the operative cholangiography or Mirizzigrafía method, which was universally adopted as the cornerstone of diagnosis. With the help of radiologists Lozada and Carlos Quiroga, he implemented the first X-ray bile duct operative system in 1931.

Pedro A. Maissa, who graduated in 1922, was an intern at the Institute of Radiology under Prof. Alfredo Lanari before serving at National Clinical Hospital. In 1934, Maissa was an assistant professor of radiology and physiotherapy, and in 1936, he was named as the head of central administration of Hospital Ramos Mejia, whose central pavilion was designed and inaugurated by himself in 1942. The university course in Medical and Technical Radiology was an initiative of Dr. Maissa, who presented the project to the Dean Dr. Escardó on 22 January 1958. The new dean, Luis Munist, M.D., approved the project on 29 April 1959. In 1972, Maissa created Foundation Maissa, and in 1980, he inaugurated the Institute of Oncology. He was awarded as the master of medicine in Argentina in 1988.

Dr. Manuel Malenchini was a man who renewed radiology in Argentina by changing static radiology with a new dynamic approach. He graduated as a physician in 1929 and presented his Ph.D. thesis the following year titled "Radiological Diagnosis of Bone Tumors." He was the physician in charge of X-rays at Nueva Pompeya Hospital. In addition, Malenchini traveled to Europe, working at Curle Foundation in Paris along with the French master radiologists. On his return, he continued under the service of Prof. Enrique Finocchietto, a teacher of many Argentine doctors. Malenchini also gained prestige as a radiologist in the United States. In Argentina, he served as the chief of radiology at the Hospital Central of Rawson and head of the Department of Radiology at Instituto Modelo, as well as conducting the Municipal School of Radiology. His vast knowledge of radiology appeared in numerous publications and more than 100 book chapters on medical pathology. He was the president

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of Sociedad Argentina de Radiología in the bienium 1959–1960.

The first radiobiological tests in Argentina were taken at the Institute of Experimental Medicine (now Hospital Roffo) in 1926. In 1949, a team from Harvard University, along with Hector Perinetti, M.D., and Central Hospital colleagues, did the first medical studies with radioisotopes, using iodine-131 to determine the causes of endemic goiter in Mendoza. This work was the first in the world to use a radioisotope in epidemiological studies.

In 1958, he started the Laboratory of Nuclear Medicine at the University Hospital, which in 1962 would become the Center of Nuclear Medicine, sustained since 1966 by the University of Buenos Aires (UBA) and National Atomic Energy Commission [Comisión Nacional de Energía Atómica (CNEA)]. In 1991, the commission, together with the University of Cuyo and the province of Mendoza, installed the Nuclear Medicine Foundation School [Fundación Escuela de Medicina Nuclear (FUESMEN)].

The Argentine Society of Ultrasound was founded in Rosario, Santa Fe, in October 1978, and its first president was Rodolfo Víctor Kleinlein, M.D., professor of semiology at Rosario National University. Prior to this, he completed a residency in Germany at the University of Erlangen to deepen his knowledge of ultrasound. Kleinlein included ultrasound as a diagnostic method in the undergraduate program and organized the First Argentinian Symposium of Ultrasound, which was also the first Ibero-American meeting on ultrasound.

### Medical Imaging and Medical Revolution

Medical imaging is advancing by leaps and bounds. Today, four-dimensional (4-D) fetal ultrasound, whole-body multislice magnetic resonance, multislice-computed tomography (CT), and 4-D echocardiography allow early detection of diseases long before the onset of symptoms. As far as diagnosis is concerned, a revolution has taken place in recent years. Globally speaking, there is a boom in terms of new diagnostic methods. Fortunately, the change came to Argentina faster than imagined.

One of the first lines of research in Argentina was quality control and instrumentation in nuclear medicine.

The 64-channel multislice-CT is a breakthrough in achieving early diagnosis and improved prognosis for patients, allowing data acquisition 64 times faster than with conventional equipment. The information necessary to allow the reconstruction of coronary tree is acquired in just 5 s and may be as short as 30 s for the whole body [2]–[6]. The Institute of Cardiology in the province of Corrientes Juana Francisca Cabral received the first equipment of this kind in Argentina in September 2005.



(a)



(b)

FIGURE 1 (a) A 1.5-T MRI scanner (Philips, Netherlands) and (b) 0.2-T open MRI scanner (General Electric) (Escuela de Medicina Nuclear, Mendoza).



**FIGURE 2** A single-head gamma camera (Elsint, Haifa, Israel) (Escuela de Medicina Nuclear, Mendoza).



**FIGURE 3** Dual-head gamma camera (Elsint, Haifa, Israel) (Escuela de Medicina Nuclear, Mendoza).

Its improved spatial resolution allows for the visualization of structures as small as 0.5 mm and performs two-dimensional (2-D) and three-dimensional (3-D) reconstructions, thanks to a powerful software platform. After 3-D image reconstruction, virtual traveling into hollow structures and vessels is possible: bronchoscopy, virtual colonoscopy, and endovascular navigation. In addition, it enables visualization of the coronary arteries noninvasively. In the case of patients with high cardiovascular risk, the 64 CT scan also provide accurate information about the existence of atherosclerotic plaques and the possible presence of coronary artery stenosis, which will undoubtedly provide very relevant information for clinical and therapeutic management. In cases of patients with coronary artery bypass surgery, the 64 multislice-CT can visualize the coronary bridges very clearly, their exact location and the possible emergence of new atherosclerotic disease over time.

Another of the fruits of continued progress is the whole-body MRI, a novel mode that provides 2-D and 3-D images, contiguous from head to toe, unlike conventional ones that can only study separate regions. With this technology, a new spectrum of diagnostic possibilities opened in the early detection of diseases that have no symptoms. The Diagnostic Center (Buenos Aires) has been applying such technology since mid-2005. Its

many clinical applications include the search for metastasis, the simultaneous study of all arteries, as well as angiography in patients with vascular risk, especially, those suffering from systemic diseases such as atherosclerosis and diabetes. It also offers an opportunity to view the whole backbone and to study common spinal disorders such as spondylosis, metastatic, or traumatic aftermath.

### Nuclear Medicine Imaging

The CNEA played a key role in the development of nuclear medicine in Argentina. Since its foundation in 1950, CNEA has fostered the research and application of radioisotopes and radiation in medicine. The Department of Biology and Medicine and Radiobiology Research Division were created in 1952 and 1957, respectively, as well as a vivarium and genetic and X-ray laboratories. As early as 1958, Nuclear Medicine Laboratory was created at Hospital de Clínicas (UBA), furnished with the state-of-the-art equipment in 1967. Since then, Nuclear Medicine Laboratory has become a reference center for regional training and education, nationally and for other Latin American countries.

In 1969, CNEA incorporated a Nuclear Medicine Center at the renowned cancer institute Angel Roffo in Buenos Aires, in association with UBA. Scintigraphic imaging and therapy—especially for the thyroid gland—was performed in both centers using rectilinear and static scanners, which comprised a single NaI crystal with a coupled photomultiplier tube and a well counter. Planar imaging began in the early 1970s, using large-area NaI crystals, with the incorporation of single-head gamma cameras, taking advantage of the Mb-Tc generators that CNEA produced and exported. A decade later, both nuclear medicine centers incorporated the first single photon emission CT (SPECT) scanners capable of producing emission tomographic slices of the whole body.

Another milestone was set when CNEA founded the first Positron Emission Tomography (PET) Center in Latin America, located in the city of Mendoza. It was hosted in a newly opened Nuclear Medicine Foundation in association with the University of Cuyo and the Provincial Government of Mendoza. This institution was a pioneer in further developments such as cyclotron–radiochemistry for positron-emitter compounds, the



**FIGURE 4** PET scanner (UGM, Philadelphia, USA) (Escuela de Medicina Nuclear, Mendoza).

double-headed gamma camera, picture archiving and communication systems (PACS), as well as continuing education and training of physicians and medical physicists.

PET is a nuclear medicine imaging technique that uses positron emitters. A ring-detector system around the patient collects pairs of 511-keV photons in coincidence (from positron–electron annihilation), and a reconstruction algorithm generates tomographic images of the distribution of a given radiopharmaceutical in the human body. The clinical applications of PET are based on the evaluation of a phenomenon using metabolic tracers. Through them, it seeks to evaluate the different processes such as the rate of cellular glucose uptake or ammonia perfusion rate. Because of its ability to detect specific regional metabolic changes, it has a greater sensitivity and specificity for detecting dementia disorders. It can perform differential diagnosis of dementias such as Alzheimer's, multiinfarct, and others. It allows the detection of focal areas of hypometabolism in generalized forms of epilepsy. Moreover, it is useful in noninvasive diagnosis of regional changes in metabolic rate as an indicator of tumor activity and in studies of tumor malignancy grades.

### Ultrasound Imaging

The 4-D fetal ultrasound is another significant advance in noninvasive medical imaging. It allows the monitoring of 3-D visualizations of the unborn child in real time. It is not an essential condition to make a 3-D–4-D ultrasound diagnostic, though, perhaps in the future, it will be part of the routine. Beyond the social impact that represents this new technology, it has other applications that will be refined further, as the 4-D study of the fetal heart detects cardiac abnormalities or hemodynamic disturbances. Recently, there are numerous public and private institutions that have this novel modality.

### Mathematics, Physics, and Electronics in Medical Image Research: A Multidisciplinary Endeavor

Historically, it has been essential for physicists, mathematicians, engineers, and medical professionals to cooperate, and indeed for the future, there will be an ongoing requirement to cross the traditional subject boundaries. In the academic and professional environment, it has increasingly become necessary for collaboration between different disciplines so as to produce innovative and enriching approaches between different areas of knowledge through scientific exchange of influences, ideas, and models. In scientific work, it attempts to harmoniously combine concepts from different disciplines such as physics, mathematics, engineering, and medicine.

In Argentina, there are several research groups in the area of medical imaging that emerge as interdisciplinary teams, and their composition varies due to historical reasons only. Electronic engineers, physicists, and mathematicians worked together prior to the creation of specialized university careers such as bioengineering. Now, young bioengineers and biomed-



**FIGURE 5** Mammography system (General Electric) (Escuela de Medicina Nuclear, Mendoza).

cal engineers have been brought together in research groups to provide an even more interdisciplinary scope.

One of the first lines of research in Argentina was quality control and instrumentation in nuclear medicine. A few groups are active in CNEA, and associated institutes such as Clínicas Hospital (Buenos Aires), Fundación Escuela de Medicina Nuclear (Mendoza), and Centro Atómico Ezeiza also services several private centers. It is important to mention that a small group of Argentine private companies also develop dedicated hardware and software to meet the specific needs.

Medical imaging research groups are concentrated in several universities and institutions around Argentina. Another active research field is the application of physical and mathematical models to carry out complex image-processing tasks of interest in medicine. Some of the current lines are

multimodality image registration, tissue segmentation, and pattern recognition.

Scientific research is supported by ordinary university budgets as well as national and provincial grants. The National Council for Scientific and Technical Research [Comisión Nacional de Investigaciones Científicas y Técnicas (CONICET)] was created in 1958 in response to the widespread social perception for the need to structure an academic institution that promoted scientific and technological research in Argentina. Its first president was Dr. Bernard A. Houssay (Nobel prize, 1947), who, with his founding imprint, instilled a clear strategic vision expressed in organizational concepts. After more than 60 years of existence, CONICET, a self-financing agency, is one of the most important national funders of science and technology.

CNEA is a self-financing agency created in 1950. CNEA's activities are developed within a legal framework, which gives full authority to act publicly and privately in the scientific, technical, industrial, commercial, administrative, and financial segments. In addition to some foundations and institutes belonging to CNEA, CNEA also provides scholarships and grants. CNEA

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has been essential in nuclear medicine and nuclear medicine imaging development in Argentina.

Apart from the former agencies, there are scientific societies where researchers, the pillars in the medical imaging field in Argentina, are grouped by thematic affinities that work in conjunction with the organizations mentioned earlier. The Argentinean Society of Bioengineering [Sociedad Argentina de Bioingeniería (SABI)] and the Argentinean Society of Medical Physics [Sociedad Argentina de Física Médica (SAFIM)] are the two societies that have had more influence in the development of medical imaging.

SABI was established in 1979 by a small group of seven young enthusiasts and visionaries belonging to the Laboratory of Bioengineering, National University of Tucumán. It is a civil society nonprofit organization, with the primary objective of promoting development of the application of sciences to solving biological and medical problems. In 1981, it hosted its first scientific meeting in Tucumán, SABI 1981. Since then, 17 more conferences have been organized. Since 1995, the society has published *Argentine Journal of Bioengineering* in which original works are published.

SAFIM is a nonprofit society founded in 1995 with the aim of bringing together all those engaged in basic or applied research topics of medical physics in Argentina. SAFIM sponsors the organization of conferences, seminars, meetings, symposiums, congresses, and courses of the specialty; linked with associations, corporations, union members, and/or any intermediate institution of Argentina or abroad. It also promotes the publication and dissemination of scientific work related to medical physics and advises and assists public and private institutions in the regulation of activities related to medical physics.

Physics of medical imaging and image processing are currently included as essential subjects at both graduate and postgraduate education programs, which must be constantly updated to keep pace with the relentless evolution of science and technology. The growing demand for specialized medical image-processing tasks such as visualization, segmentation, analysis, registration, and management is encouraging young researchers to join in this venture and also the governments to support this field, as more sophisticated equipment becomes available. All new development in these directions represents a contribution to the analysis and systematization of knowledge discovery and information that contains medical images. These developments have improved the study, diagnosis, and monitoring of various diseases, resulting directly or indirectly in a better quality of life we all deserve.

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digital image processing at the Electronics Department of UNMdP. She directs the image processing area at the Electronics Department of UNMdP. She authored and coauthored several peer-reviewed publications, including two book chapters. She is the secretary of the Argentinean Society of Bioengineering and also a member of the IEEE Engineering in Medicine and Biology Society. She has been a vice dean of the Faculty of Engineering of UNMdP since 2008. Her research emphasis is in mathematical morphology, pattern recognition, and medical image processing.

**Roberto A. Isoardi** received an M.Sc. degree in physics from Instituto Balseiro, where he just completed his Ph.D. thesis on medical image analysis. He has been a researcher of CNEA at Nuclear Medicine School Foundation in Mendoza, Argentina, since 1992. His education on medical imaging includes training fellowships at the University of Pittsburgh Medical Center and Service Hospitalier Frédéric Joliot, Orsay, France. He authored and coauthored several peer-reviewed publications, including two book chapters. He has been a member of the IEEE Nuclear Science and Plasma Society since 1997.

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