

In Memoriam Raymond V. Damadian, M.D. (1936 - 2022)

Brianna E. Damadian,¹ Jay Dworkin,²
Jay Butterman,² Anthony Giambalvo,²
David Chu²

¹Northwell Health/Lenox Hill Hospital,
Department of Radiology, New York,
USA; ²FONAR Corporation, Melville,
USA

Dr. Raymond Damadian, inventor of magnetic resonance imaging (MRI), passed away unexpectedly on August 3, 2022. Recognized as a brilliant inventor and compassionate physician, he was still actively working on his MRI research program at FONAR Corporation, the company he founded in 1978. He was also a devoted husband, dedicated father of three children, grandfather, great-grandfather, brother and uncle who cherished and deeply loved his family.

In his 86 years of life, Dr. Damadian accomplished more than most could dream. He was born in 1936 to Vahan and Odette Damadian, both Armenian-Americans. He spent his childhood in Forest Hills, New York, playing with and watching over his younger sister Claudette. He studied violin at The Juilliard School until winning a Ford Foundation scholarship to the University of Wisconsin at the young age of 15. After graduating college with a degree in mathematics, he earned his medical degree in 1960 from the Albert Einstein College of Medicine in New York.

His initial academic research focused on the roles of sodium and potassium in living cells,¹⁻² first as a Biophysics Fellow at Harvard University and later as a faculty member at Brooklyn's SUNY Downstate

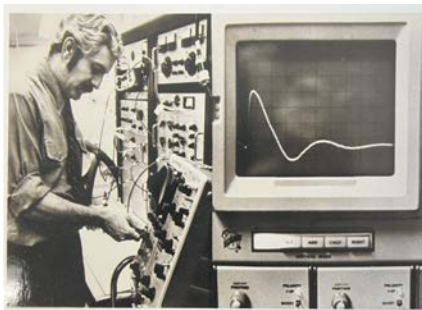


Figure 1. Dr. Damadian discovers the significant difference between relaxation time in normal and diseased human tissue.

Medical Center. It was there that he was introduced to a technology called nuclear magnetic resonance (NMR), which was able to detect radio signals from the contents of a test tube in order to help identify its chemical makeup. He was stunned by this tool that scientists had been using for years. He imagined using it on a larger scale to look inside the body. He first proposed the magnetic resonance (MR) body scanner in 1969.

Dr. Damadian's 1971 publication in the journal *Science*³ entitled *Tumor Detection by Nuclear Magnetic Resonance* began with these prescient words: "At present, early detection of internal neoplasms is hampered by the relatively high permeability of many tumors to x-rays. In principle, nuclear magnetic resonance (NMR) techniques combine many of the desired features of an external probe for the detection of internal cancer."

He filed the first patent in the field of MRI in 1972, proposing the concept of using NMR for detecting cancer;⁴ it was subsequently issued in 1974. His intense passion for trying to cure cancer^{5,6} led to the invention of a machine that has undoubtedly impacted and saved millions of lives. He and his team built a homemade supercon-



Figure 2. Dr. Damadian risks his life as the first human to attempt being scanned in an NMR scanner. A cardiologist (left) stands by in case of emergency. This scan did not lead to a diagnostic image. The first human MRI image was subsequently acquired of Damadian's graduate student, Lawrence Minkoff, on July 3, 1977. Dr. Damadian monitored the now Dr. Minkoff overnight at his home to observe for any ill effects of this new technology.

Correspondence: Brianna E. Damadian, MD
100 E 77th Street, New York, New York
10075

Tel.: (212) 434-2000
bdamadian@northwell.edu

Key words: magnetic resonance imaging;
cerebrospinal fluid flow; multiple sclerosis.

Contributions: All authors contributed to the research, writing, and editing of this correspondence

Conflict of interest: The authors of this correspondence are shareholders and/or employees of FONAR Corporation.

Availability of data and materials: All data generated or analyzed during this study are included in this published article.

Received for publication: 6 September 2022.
Accepted for publication: 6 September 2022.

This work is licensed under a Creative Commons Attribution 4.0 License (by-nc 4.0).

©Copyright: the Author(s), 2022
Licensee PAGEPress, Italy
Veins and Lymphatics 2022; 11:10844
doi:10.4081/vl.2022.10844

Publisher's note: All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article or claim that may be made by its manufacturer is not guaranteed or endorsed by the publisher.



Figure 3. Dr. Damadian (left) and his research team, Lawrence Minkoff (middle) and Michael Goldsmith (right) alongside the first MRI scanner, which they aptly named *The Indomitable*.

ducting magnet large enough to accommodate a human being, and on July 3, 1977 they achieved the world's first MRI scan of a human body.

Dr. Damadian then founded a company to commercialize the technology. FONAR Corporation was incorporated in 1978 and sold its first commercial MRI scanner in 1980. For over 40 years, Dr. Damadian poured his heart and soul into his company. All of his employees and the countless number of people helped by the MRI are the embodiment of his life's work, as are the more than 115 United States Patents on which he is either a sole author or co-author. He was also the recipient of many national and international awards.

In 2011, Dr. Damadian published a study⁷ utilizing FONAR's UPRIGHT® MRI that showed eight patients with Multiple Sclerosis (MS) had degenerative changes in the cervical spine that impinged on the spinal canal and limited the pulsatile flow of the cerebrospinal fluid (CSF) lubricating the

brain and spinal cord. His team was able to view this CSF flow in and out of the brain with the patients positioned both lying down and upright. It was increased resistance to the outflow of CSF, he suggested, that played a role in the development of MS in these patients. Interestingly, his theory about MS was similar to Dr. P. Zamboni's work proposing that MS is due to the impeded outflow of venous blood from the brain due to dural sinus stenoses.⁸⁻¹⁰

This work became one of the catalysts for Dr. Damadian's intense interest, during the later part of his life, in how the human body's position influences CSF circulation between the brain and spinal canal. When the FONAR UPRIGHT® MRI was used to examine patients and visualize these differences, the results revealed a promising indication for future studies to investigate the CSF-posture correlation in brain waste clearance and aging, as well as in a range of different neurodegenerative ailments.¹¹

While the world has lost the Father of the MRI, Dr. Damadian's legacy lives on through his revolutionary invention and its many applications to diagnose and cure human disease. To honor the enormous contribution he made to medicine and mankind, may the scientific and medical community continue to explore, innovate, and cure disease with this technology for years to come.



Figure 4. Dr. Damadian poses next to The Indomitable, on display at The Smithsonian Institution.

References

1. Damadian R, Solomon AK. Bacterial Mutant with Impaired Potassium Transport and Methionine Biosynthesis. *Science* 1964;145:1327-8.
2. Cope, FW, Damadian R. Cell potassium by 39K spin echo nuclear magnetic resonance. *Nature* 1970;228:76-77.
3. Damadian R. "Tumor detection by

nuclear magnetic resonance. *Science* 1971;171:1151-1153.

4. U.S. Patent 3,789,832, Raymond Damadian, Apparatus and Method for Detecting Cancer in Tissue, Filed 1972.
5. Damadian R et al. Human Tumors Detected by Nuclear Magnetic Resonance. *Proceedings of the National Academy of Sciences* 1974;71:1471-1473.
6. Damadian R. Field focusing n.m.r. (FONAR) and the formation of chemical images in man. *Philosophical Transactions of The Royal Society Biological Sciences*, London 1980;289:489-500.
7. Damadian RV, Chu D. The possible role of craniocervical trauma and abnormal CSF hydrodynamics in the genesis of multiple sclerosis. *Physiological Chemistry and Physics and Medical NMR* 2011;41:1-17.
8. Zamboni P. 2018. The contribution of extracranial venous drainage to neuroinflammation in multiple sclerosis. In: Minagar A, ed. *Neuroinflammation*. London: Elsevier; 579-599.
9. Haacke EM et al. The role of magnetic resonance imaging in assessing venous vascular abnormalities in the head and neck: a demonstration of cerebrospinal venous insufficiency in a subset of multiple sclerosis patients. *Veins and Lymphatics* 2015;4.
10. Zamboni P et al. Effects of Venous Angioplasty on Cerebral Lesions in Multiple Sclerosis: Expanded Analysis of the Brave Dreams Double-Blind, Sham-Controlled Randomized Trial. *Journal of Endovascular Therapy* 2020;27:9-17.
11. Muccio M et al. Upright versus supine MRI: effects of body position on craniocervical CSF flow. *Fluids and Barriers of the CNS* 2021;18:61.