Thousander Paulo C. Duarte Jr., PhD: Engineering the Impossible

by Paulo C. Duarte Jr., PhD, MSPE

Dr. Duarte with his son, Paulinho.

The journey of Dr. Paulo C. Duarte Jr. into cardiovascular bioengineering began with his son. During his wife's pregnancy, Dr. Duarte and his family learned that the baby had hypoplastic left heart syndrome, a severe congenital heart defect that would require a sequence of major surgeries during the first years of life.

Dr. Duarte was a civil engineer and entrepreneur. His training had prepared him to deal with complex problems, investigate causes, test alternatives, and understand how systems behave before intervening in their processes. This problem, however, was in his son's heart.

In the months and years that followed, three words became a major part of the family's life: *Norwood*, *Glenn*, and *Fontan*—three major surgical stages. His son went through them all.

As he followed his son's treatment, Dr. Duarte began asking questions. *Why were three surgeries necessary? Could engineering help physicians better understand the circulation before an operation? Could different possibilities be tested before taking them into the operating room?* Then came the question that would shape much of his scientific life: *Could there be a different path?*

A father's search for answers changed his professional trajectory. Dr. Duarte returned to university, completed a master's degree, and redirected his studies toward bioengineering. During his PhD schooling, Dr. Duarte began using computational tools to virtually study blood circulation and different surgical possibilities. That research led to a surgical planning method for the Fontan circulation, which was later published in the *Brazilian Journal of Cardiovascular Surgery*.[1] The method uses engineering to study a surgery before it is performed by comparing different possibilities and anticipating aspects of postoperative outcomes, thus providing additional information for medical planning. Dr. Duarte's

second study on the subject, which was published in *Medical Engineering & Physics*, investigated ways to make these simulations simpler and more accessible, identifying the levels of complexity needed to produce useful information.[2] His research continued to move forward.

During his postdoctoral research at the Dante Pazzanese Institute of Cardiology, Dr. Duarte returned to the question that had followed him from the beginning: *Why three surgeries?* From that question came a more ambitious proposal. Dr. Duarte and his partners began studying the possibility of replacing the traditional sequence of *three* surgeries with a *single* strategy performed during the neonatal period, capable of progressively adapting to the child's growth and physiological changes. This proposal resulted in the article, "A Translational Paradigm for Univentricular Heart Disease: Single-Stage Neonatal Repair with Adaptive Control of Cavopulmonary Flow," which was published in 2026 in *Cardiovascular Engineering and Technology*.[3]

Via engineering, Dr. Duarte began to investigate a surgery that does not yet exist. Advancing this proposal brought together engineers, physicians, surgeons, biologists, chemists, veterinarians, materials specialists, and researchers from different fields. This experience strengthened one of Dr. Duarte's convictions: *The hardest problems rarely respect the boundaries we create between disciplines*.

This view inspired Dr. Duarte to pen his letter to the editor, "Between Hearts and Gears: Technology at the Service of Life," which appeared in 2026 in the *Brazilian Journal of Cardiovascular Surgery*.[4] The text of the letter advocates bringing engineering, medicine, and technology together around a common purpose: expanding our ability to understand problems, plan interventions, and develop better solutions for patients. Engineering and medicine work better together.

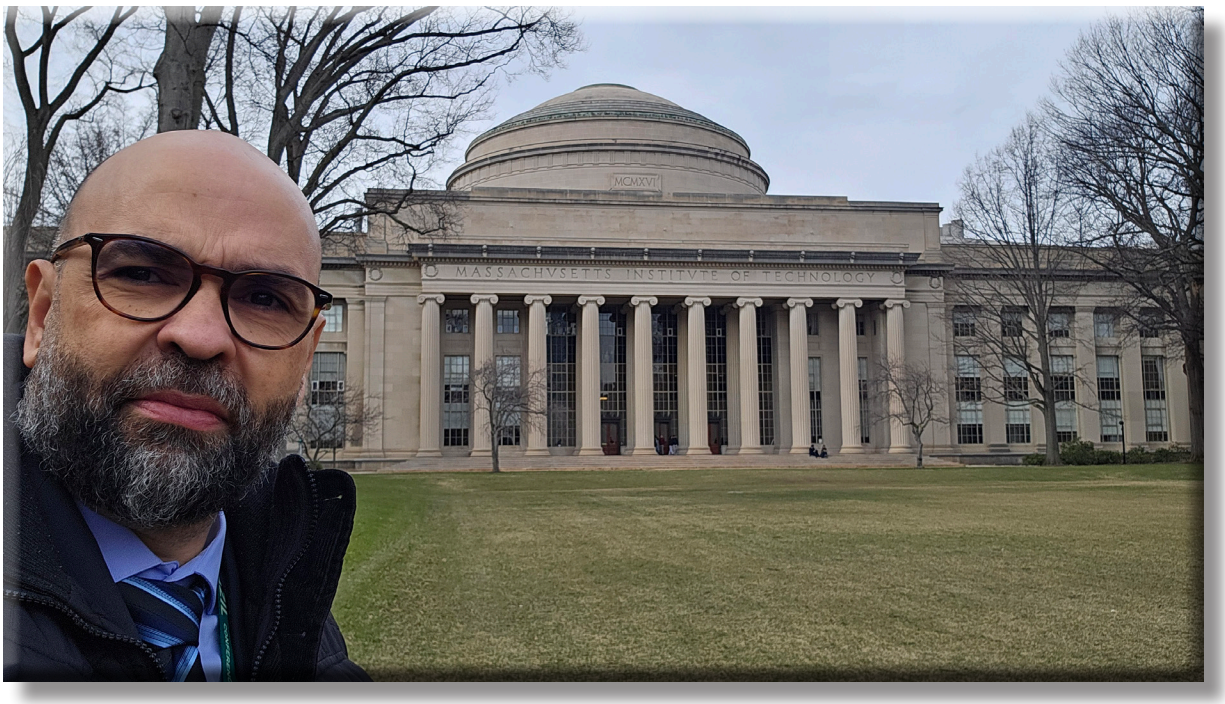
The quest that began within his own family received growing academic and scientific recognition. Dr. Duarte's doctoral thesis received an honorable mention in the 2024 CAPES Thesis Award. In the same year, he received first place in the Independent Inventor category of the Paraná Science and Technology Award. His trajectory was also recognized by Londrina—the city where he built much of his personal, professional, and academic life—with the title of Honorary Citizen of Londrina.

Dr. Duarte with his parents and children during the ceremony in which he received the title of Honorary Citizen of Londrina.

In 2026, Dr. Duarte's research received the Researchers Grand Prize at the Brazil Conference. The recognition took him to Cambridge, Massachusetts, where he presented and discussed his work at both Harvard and MIT. The photographs taken there captured a special moment in a journey that had begun many years earlier, when a father began trying to understand his own son's heart.

Dr. Duarte also participates in the MIT Regional Entrepreneurship Acceleration Program—MIT REAP—at Northern Paraná, contributing to stronger connections among universities,

(Above and below) Dr. Duarte in Cambridge, Massachusetts, 2026. The research journey that began with his deeply personal experience reached both Harvard and MIT.



Dr. Duarte's articles, research, awards, and recognitions all share a common origin: his son.

companies, government, investment, and innovation. He also serves as a peer reviewer for various scientific journals. Peer review is part of his understanding of the responsibility involved in producing science: submitting ideas to criticism, revising concepts, correcting paths, and contributing to the improvement of work developed by other researchers. As a professor and invited speaker, Dr. Duarte brings this same perspective to scientific, academic, business, and public audiences.

His son, Paulinho, was the beginning of his journey. Today, Dr. Duarte's work is focused on children with congenital heart disease who have yet to be born, families who will receive those difficult diagnoses, and the physicians and surgeons who work every day to save them.

The Norwood, Glenn, and Fontan surgeries saved his son's life. Today, Dr. Duarte works to build the next step. The proposal to replace the three surgical stages with a single neonatal strategy has already been presented. The challenge now is to turn that proposal into reality. This purpose also connects to a broader dream: helping create, in Northern Paraná, a bioengineering center with international reach, bringing together different fields of knowledge to transform real medical problems into research, inventions, and accessible solutions.

In the beginning, Dr. Duarte wanted to understand his own son's heart. Today, he uses what he has learned to help other hearts. His journey can be summarized in one expression: "Engineering the Impossible." Engineering is limited only when our willingness to solve problems that matter comes to an end.

What began with the need to understand one child's heart became a much larger purpose.

NOTES

1. Paulo C. Duarte Junior et al., "Fontan Surgical Planning: Numerical Simulations Reveal Efficient Geometries Predicting Post-Surgical Outcomes," *Brazilian Journal of Cardiovascular Surgery* 40, no. 2 (March 18, 2025), doi:10.21470/1678-9741-2024-0217.

2. Paulo C. Duarte Junior et al., "A Multiparameter Comparative Approach to the Three-Dimensional Numerical Analysis of the Hemodynamics of Total Cavopulmonary Connection," *Medical Engineering & Physics* 139, no. 104331 (March 28, 2025), doi:10.1016/j.medengphy.2025.104331.

3. Paulo C. Duarte Junior et al., "A Translational Paradigm for Univentricular Heart Disease: Single-Stage Neonatal Repair with Adaptive Control of Cavopulmonary Flow," *Cardiovascular Engineering and Technology* (August 18, 2026), doi:10.1007/s13239-026-00856-8.

4. Paulo C. Duarte Junior et al., "Between Hearts and Gears: Technology at the Service of Life," *Brazilian Journal of Cardiovascular Surgery* 41, no. 2 (December 10, 2025), doi:10.21470/1678-9741-2025-0167. Ω