

From imaging tools to a Clinical Trial Digital Twin

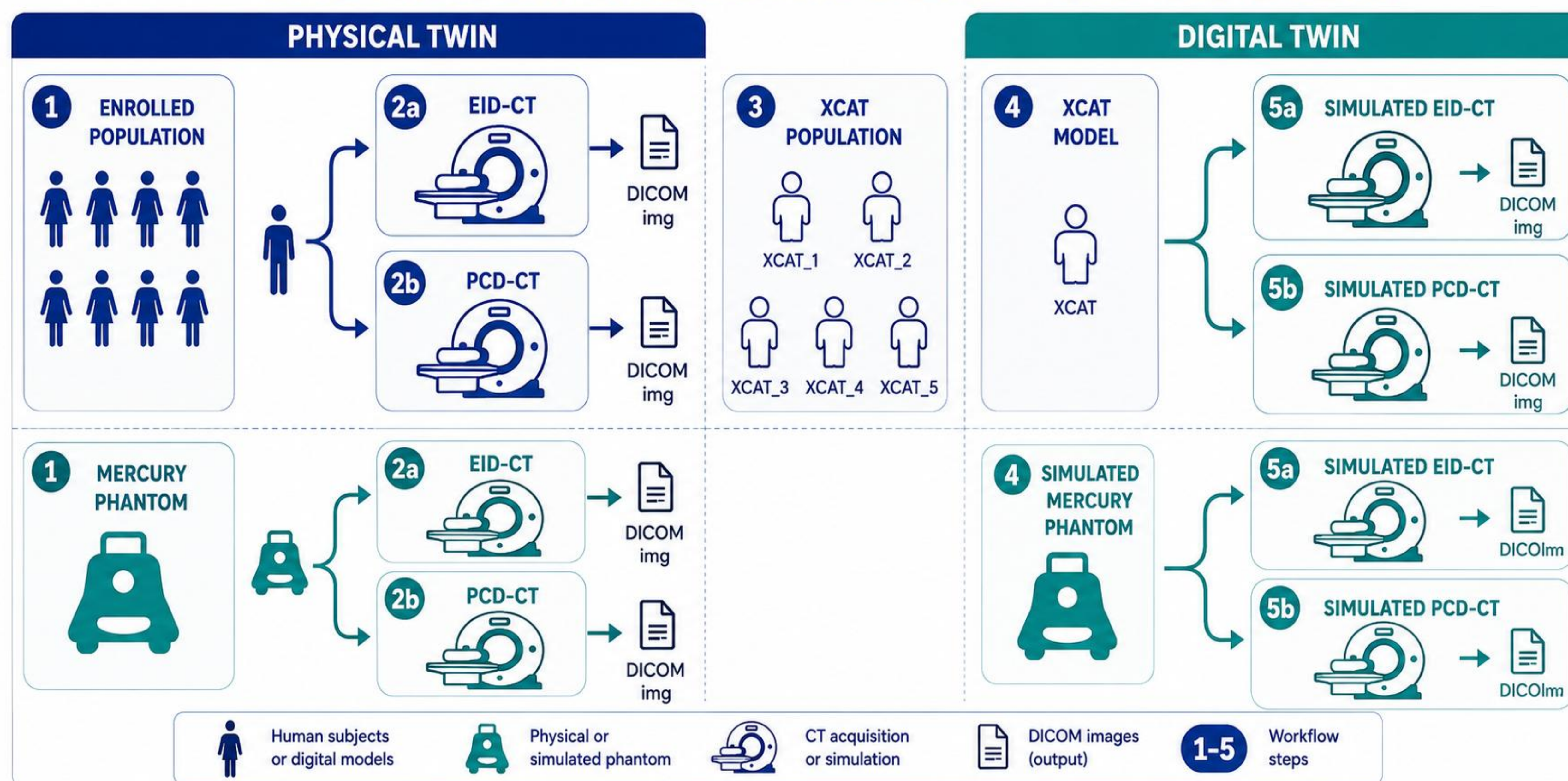
The growing adoption of Digital Twin technologies in healthcare highlights the need to define how medical imaging tools (physical and digital phantoms, real and simulated CT studies, etc.) integrate with the virtual components of Digital Twins.

This work applied a **conceptual healthcare Digital Twin Framework** to the design of a **clinical imaging trial** comparing photon-counting CT and energy-integrating CT in chest examinations.

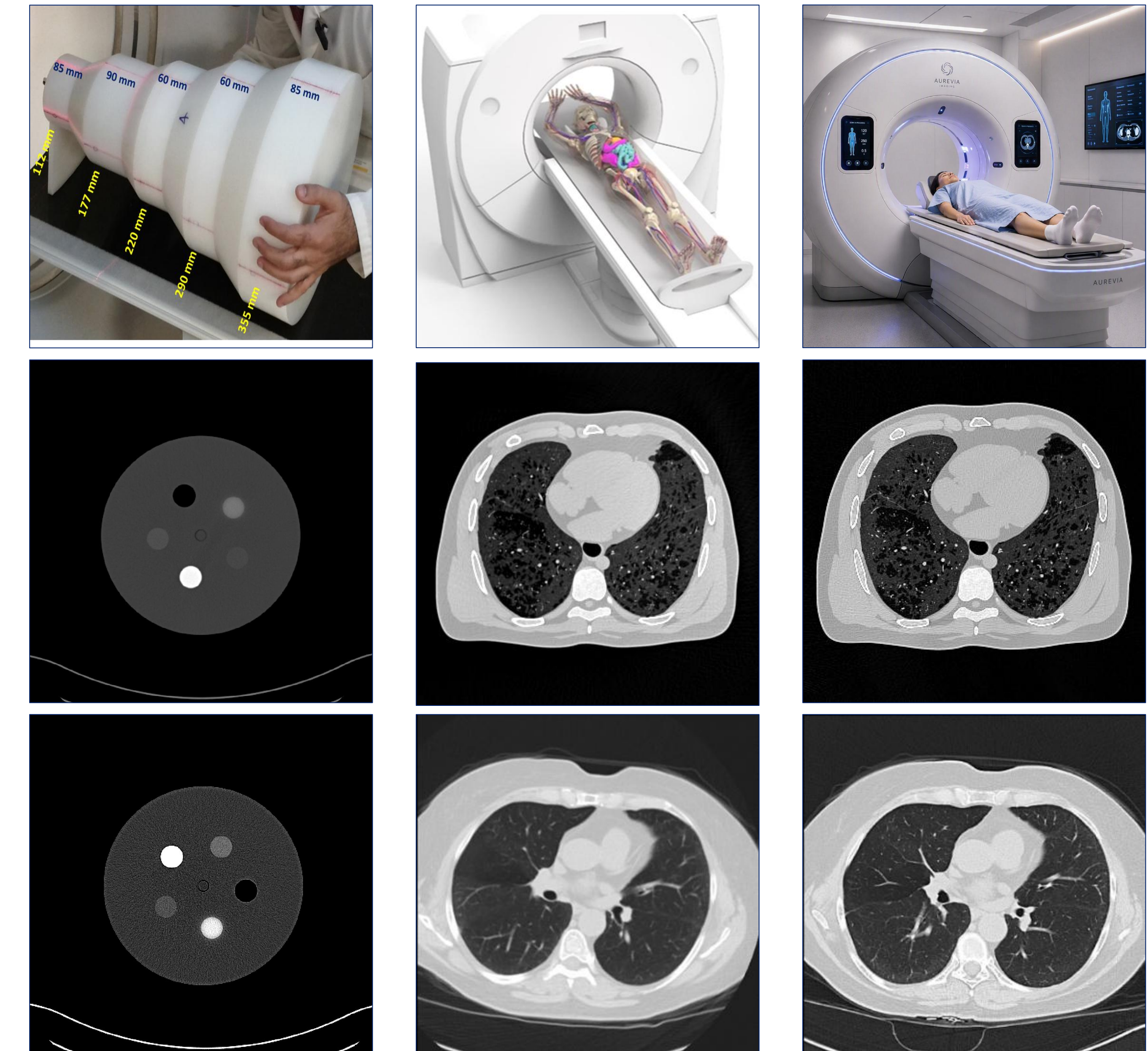
The proposed Clinical Trial Digital Twin integrated the enrolled patients, the Mercury-3.0 physical phantom, XCAT computational phantoms, CT scanners, acquisition workflows, and real and simulated imaging studies **within a unified representation of the trial**.

The resulting architecture **connects the physical trial with its virtual counterparts**, enabling the analysis, simulation, and optimization of imaging procedures.

STUDY DESIGN: PHYSICAL AND DIGITAL TWIN WORKFLOWS



Conceptual representation of a healthcare digital twin framework. A physical patient is linked to a virtual anatomical replica through continuous, bidirectional data exchange with a cloud-based computational infrastructure. Multimodal clinical information, including physiological signals, medical records, and molecular data, is integrated to update the digital model over time. The resulting patient-specific representation can support real-time monitoring, predictive simulation, clinical decision-making, and personalized healthcare interventions.



PCD-CT and EID-CT were compared using a physical phantom (Mercury-3.0), five anthropomorphic computational phantoms (XCAT), and real patients undergoing chest CT on both PCD-CT and EID-CT.

Implications

A **Clinical Trial Digital Twin** in healthcare can represent the **real scenarios through an integrated combination** of real patients, patient simulators, and medical imaging systems.

This approach supported **controlled population augmentation**, improved the **evaluation of imaging protocols**, and provides a structured basis for the **operationalization of Digital Twins** in clinical imaging trials.

The framework provided a **structured and generalizable basis** for the development of Digital Twins in medical imaging.