Medical Xpress

Mathematical method builds synthetic hearts to identify how heart shape could be linked to disease

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Researchers from King's College London have created 3D replicas of full-sized healthy adult hearts from Computed Tomography (CT) images and analyzed how cardiac shape relates to function.

Published today in *PLOS Computational Biology*, the study also includes 1000 new synthetic hearts that have been made open access allowing researchers to download and use them to test new algorithms, test in-silico therapies, run more statistical analyses or generate specific shapes from the average models.

Statistical shape analysis is a technique that allows the rigorous study of the anatomical changes of the heart across different subjects. Using this technique, from a cohort of 20 healthy adult hearts the researchers created an average heart and then adjusted by deforming this average heart to get 1000 new and synthetic 3D whole hearts.

By making the synthetic heart divert from the average shape more abnormal or extreme hearts can be created, bounded by the range of variation observed in the cohort.

Lead researcher Cristobal Rodero said: "Even in healthy people, everyone has a slightly different heart shape. Knowing these differences and how they affect cardiac function is a task for which computer simulations are an ideal tool."

With the data, researchers can run electro-mechanic simulations on the 20 hearts plus 38 extreme cases where some features, automatically selected, were exaggerated such as bigger or smaller hearts or with thicker walls.

Mr Rodero said the research is the first milestone in our understanding of how subtle anatomical changes can impact function and paves the road for other researchers to replicate and expand study results.

"This research could be used as an early diagnosis later down the track. For instance, we found that there is an area in the heart right before the aorta that when it gets thicker, it has a big impact in the predicted function."

"This anatomical trait has strong links with the latest results of my colleague Maciej Marciniak in the study of local hypertrophy patterns, also published in his recent study in the *Journal of Hypertension*."

The core of the study is based on the ability to simulate the heartbeat by computer, a complex process that requires supercomputers (more than 200,000 hours of computations that are run in parallel and take about 5 days).

The trick is then to learn the mechanisms that are simulated in what are called emulators that produce the simulation output in a split second.

Building these emulators not only expedites the process, but also the way to identify which are the important factors linked with cardiac health and disease, and how this study tackles the complex problem of how cardiac shape relates to function.

The vision in this research field is a future where our digital twins, our personalized computational replicas, support the decisions in the management of cardiovascular disease, as authors described in a white paper at the *European Heart Journal*.

Provided by King's College London