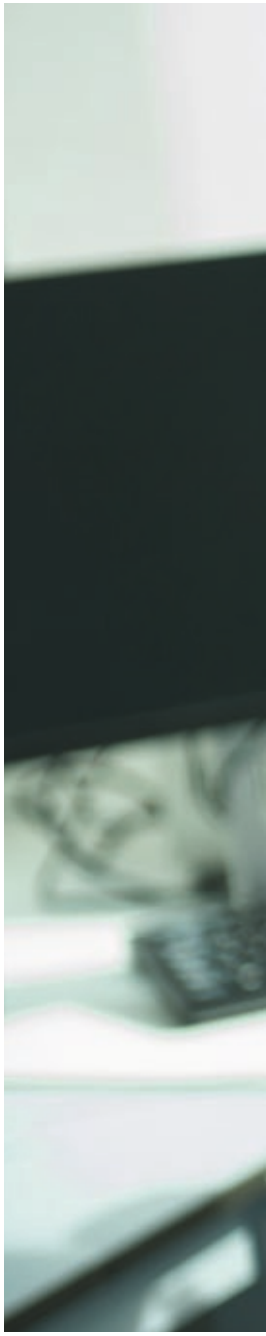
Solutions for Individual Patients

In order to tailor cardiological treatment much more closely to the individual patient, scientists at the Clinic for Cardiology at Heidelberg University Hospital, Germany, are working to develop a digital twin of the heart. Professor Benjamin Meder, Deputy Medical Director of the Department and Head of the Institute for Cardiomyopathies in Heidelberg, reveals how far the work has advanced.

Text: Philipp Grätzel von Grätz | Photos: University Hospital Heidelberg



Professor Meder, just what exactly is a digital twin of the heart?

Prof. Dr. Benjamin Meder: The term 'twin' is symbolic for the representation of a patient that closely reflects the structure and function of his or her heart and potential heart disease. The digital twin is an incredibly individualized approach in medicine. And we not only want to use it for diagnosis, but also for testing the safety of treatments. For example, we could test certain cardiac drugs on a digital twin's heart to see how effective they are. Or we could digitally simulate cardiac catheter interventions and heart surgery in advance and only go ahead with them if there's a realistic chance of success. For this to work, we need to simulate the biology of the real heart as accurately as possible, which is why molecular information, alongside clinical investigations, is certainly useful.

So can a digital twin of the heart go beyond other models of cardiovascular risk prediction?

Meder: Cardiology uses various risk models. For example, measuring the highly sensitive troponin or the ejection fraction of the left ventricle already tells us a great deal about a person's risk of disease. But in individual patients, this simplification to a few variables is often not meaningful enough to predict the effectiveness of a therapy. In the future,

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more complex models such as a digital twin of the heart could allow us to test a variety of therapy options in advance. What's important here is that we find solutions that suit an individual and not just general statements that match a risk group.

You've been working on this project for around six years. What were the major challenges?

Meder: In addition to all the technical challenges, we need to ensure reliable cooperation between different areas of expertise. This includes the cooperation between industry and the university. I think that in the future we'll need to work together much more closely when it comes to Artificial Intelligence, or AI, because each field has unique capabilities and offers its own approach to solutions. The strengths of physicians lie in the recognition of medical needs and ethical questions, in the precise path to a solution without disregarding risks. In Heidelberg, we also have decades of expertise in molecular cardiology and understand very well how diseases progress from cause to organ failure. The strengths of industry lie in knowing how to implement technology.

What specific applications for the digital twin are you working on?

Meder: First of all, thanks to AI technologies, better diagnostic methods that can integrate a huge amount of data will be available in the near future. Algorithms will also help us track the distinct progression of heart diseases and adapt those learnings to each new patient. Moreover, I think it's important, especially in the simulation of procedures using heart catheters or surgery, to avoid risks and carry out the intervention as good as possible. When you perform a heart operation or intervention, everything must be just right. You don't have a second and third chance like with repairing a car, so therapies with a certain risk have to be planned in advance and, ideally, simulated for outcome. Already today, an interventional cardiologist mentally simulates an upcoming intervention. But wouldn't it be great if this 'biological simulator' always had the same quality? To get closer to this, Heidelberg has now announced an opening for a professorship in 'Artificial Intelligence in Cardiovascular Medicine' and established the 'Informatics for Life' program, which brings together a large number of talented cardiac and computer researchers – and hopefully also the best companies as partners.

What's the current status of the project? Have algorithms already been developed for certain predictions or simulations?

Meder: We'll be building a new cardiac center in Heidelberg that will not only provide excellent cardiac medicine, but also serve exactly that purpose. Data should be used in the patient's interest, in a protected and trustworthy environment to develop cardiac medicine 4.0. Only companies with the same high standards can become partners in this set-up. One specific algorithm that we're already evaluating concerns the prediction of cardiac resynchronization therapy (CRT). This is, so to speak, our pilot project, and we're working on it together with Siemens Healthineers – as presented recently at a conference at the renowned Isaac Newton Institute in Cambridge. The challenge with CRT is that we haven't been able to accurately characterize the patients who benefit from this treatment. As a result, patients receive implants without much benefit, and patients who might benefit aren't receiving them or receive them too late. Here we want to use the digital twin to make sure we can treat patients in a more targeted way. The first study on this question is currently in data evaluation. We hope that we'll be able to publish the results soon.

Are there specific challenges to the clinical application of such algorithms? And what implications do they have for clinical trials?

Meder: Clinical trials allow the objective testing of new procedures and must precede any routine treatment. But in the age of precision medicine, the studies will look different, in particular with great importance attached to understanding the individual study participant as best as we can. The approach of the digital twin alone helps in this respect. In fact, I'd argue that there isn't a comparable approach worldwide that can better understand the heart diseases of individual patients. Hopefully the next few years will show that this can make a significant contribution to cardiac health.