Science AMA Series: I'm Natalia Trayanova, a professor of biomedical engineering and medicine at Johns Hopkins University. I create virtual hearts to diagnose and treat patients with heart rhythm disorders. AMA!

$HopkinsMedicine_A MA^1 and r/ScienceAMAs^1$

[1] Affiliation not available

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Abstract

Hi Reddit, my name is Natalia Trayanova, and I'm a professor of biomedical engineering and medicine at Johns Hopkins University. My lab uses predictive computer simulations to generate personalized virtual hearts of patients that have life-threatening arrhythmias. These first-of-their-kind virtual hearts are already being used in the clinic to assess patient risk of sudden cardiac death and to guide personalized anti-arrhythmia interventions. Simulation-driven engineering has put rockets in space, and airplanes in the sky. We trust engineering advances with our lives, however, when it comes to our own health, things are quite different. Computer simulations are rarely used in medicine. Our vision is to change this – we aim to bring computer simulations to the clinic, to make precise decisions for treatments for heart disease. We believe implementing an engineering data-driven simulation approach will increase the efficacy of diagnostic and clinical procedures for heart rhythm disorders and democratize the delivery of cardiac healthcare. You can learn more about our virtual heart approach in a recent TEDx talk [https://www.youtube.com/watch?v=wSDMPxGGy3A], and in this video describing our pioneering approach [https://youtu.be/bX62KNOfdBs]. We hope our virtual hearts will become a routine tool in the clinic, improving patient outcomes, which would be an unprecedented merging of computational simulation and clinical medicine. It has been extraordinarily fulfilling to have transcended my role as scientist and engineer, to be working directly with physicians helping patients. This is an unexpected and an exhilarating place to be. I look forward to having you #AskMeAnything on April 2nd, 1 PM ET.

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I studied biomedical engineering in college and am now working as a med device engineer at a company that focuses on the cardiovascular system, so I'm super excited for this AMA!

One of the things we have struggled with is widespread adoption of new technology in the medical field. No matter how amazing our technology is, there are physicians who seem to resist it purely because it is new and not what they are used to. How has this resistance to adoption of new therapies/technologies affected your research and what are the strategies you use to spur adoption?

Bonus question: What has your experience been like as a female engineer and researcher? Could you describe one of the biggest challenges you have faced and how you overcame it?

realjasnahkholin

For your first question, we don't have a process set up for adoption into the clinic. Our work is still in the early stages, and we are working on an uncharted path because we are working with a simulation rather than a new drug or a tool. For us, the first thing we had to accept was that the process of converting ideas from basic science to clinical technology is a slow process. You have to keep on

repeating your ideas to your clinical partners and find new ways to talk to clinicians in a language they understand. I am non-stop at clinical meetings - I go to every one that I am invited to and I try to convey what we are doing in simple terms, which has helped me get a lot of people on board. It's a tiered approach, once you get your partners to not just be willing to participate, but to be excited to be part of that process, they can bring it to their colleagues in other places. I've had a lot of success with this and we've been contacted from people from other medical centers looking to work with us. Eventually, I hope that there will be a change from this stepwise process and a company will pick it up and make a usable clinical tool with our tech.

For your second question - I am a very determined, goal-oriented person. I determined my career path and have kept my eyes on the goal. I think that has helped me to ignore the negative stuff. There is sexism everywhere - and everytime someone doubted me, i told myself that I'll show them later. And it has worked for me so far, and these negative experiences hasn't held me back.

I love working with my female students - they are go-getters and I feel like they know how to work with me. I work to promote strong female characters like that who are able to stand their ground and know what they want. And there are definitely more female students in engineering nowadays, but we now have to find a way to promote this level of diversity at the faculty and leadership level.

Hello Professor Trayanova! This sounds like amazing work! As a paramedic, my question is more geared towards the anti-arrhythmia goals of your work. I know you said personalized, but are your goals to provide more specifically targeting medications and move away from drugs like blockers & dig, or are you looking for physical procedures done on the myocardium like ablations?

What kind of impact do you see this having on acute dysrhythmia treatment in the prehospital setting?

Snakeobich

My work is focused more on physical procedures on the heart - specifically looking at whether a defibrillator device should be implanted and what is the optimal way to ablate an arrythmia. I hope that my simulations will prevent unnecessary implantations of devices, and will ensure an optimal personalized ablation treatment for each patient.

For instance, on an annual basis, only one out of twenty patients who receive a device actually need them. These patients can have major complications without deriving benefit from the device. You can learn more about this on my TED talk [https://www.youtube.com/watch?v=wSDMPxGGy3A].

For the second part of your question, we can't yet do too much in a pre-hospital setting because the paramedic or caregiver might not have access to information about the patient. The patient might need to be scanned or otherwise examined at the hospital to provide input for the model.

In the future, I Imagine that there would be data on the cloud for every patient. If the patient has been seen before at the hospital and has a virtual heart on the record, paramedics would be able to better gauge potential reasons for that patient's condition.

How would this translate to other organs with regard to currents? I'm a brain guy, and I wonder how something like this could lead to a better understanding of neurological damage, given that the brain is, at its simplest form, a really complex circuit.

musicneuroguy

The general approach is translatable to other excitable - tissue organs. Our virtual heart approach provides an example of how that can be done in other organs. However, the brain is the most complex.

Building a model like the virtual heart we have created requires a lot of knowledge about the physiology and physics of the processes taking place in the organ. I don't think we are there yet with the brian. As I don't think we have acquired the necessary information about the structure and interconnectivity of the circuits in the brain. I believe other organs may become "virtual" before the brain does.

I've been trying to invest in life-extending tech for a decade. Had some decent luck with HGSI. Where would you invest, long term?

tysc3

For long-term investment, I am definitely committed to the heart and will continue to try moving this technology forward. Cardiovascular disease is still the #1 cause of death in the world and there are a number of cardiovascular diseases that we don't know a lot about yet that will need to be studied and modeled by the virtual heart approach.

How do you see liability working? That is, if your simulations are too complicated for the prescribing physician to understand (very few would have the necessary quantitative background), who takes responsibility for any errors in cases of bad patient outcomes?

For traditional devices/diagnostics there is often a clear specification of correct working order. If an MRI returns a distorted scan, or a blood test comes back wrong, or a pacemaker fails to deliver the correct charge, there is in principle an objective criterion for declaring the service faulty and not the physician's judgement. A physician wouldn't need to know the engineering details to know what the device is supposed to provide. But in your case it seems like you'd have to argue for something like model goodness of fit, or correctness of some computational approximation used in the simulation, which doesn't seem as well established in medical practice.

Since presumably you want to inform the physician's decision, as opposed to simply telling them what to do, does that put special demands on modeling/research skills for physicians?

zetephron

In the clinic, physicians won't see the complexity of the model of their patient - they just see the treatment plan, like the targets of ablation. We hope for this to be a tool for physicians. If they disagree with our predictions, they can make their own decisions for patient care.

It is important to understand that our tool is useful for the patients for whom the current standard of care fails. Typically those patients have undergone several re-do procedures. For these patients, there is no longer a standard path.

In regard to your other points, one of the studies I am doing requires FDA approval before it receives IRB approval from the patient care committee at Hopkins. Only when the FDA pre-approves the study, after looking at it from all sides and determines that there will be no harm to patients in the clinical process, can we continue to expand the application of our technology.

How accessible is this wonderful technology? Is this software able to run on computers that are already in use in many if not most hospitals? Does it require extraordinary processing power?

PansexualEmoSwan

Right now, it runs on the super computing system on the JHU campus. But it is still a research

software at this point - which is always bulkier and heavier because we need every tiny detail. I even have ionic transport across cell membranes in there because we aren't sure what we will need and what we won't. It sometimes can take a few days to create and make predictive simulations for a patient's heart because of all of the detail.

If our approach is going to be widely implemented in the clinic, the processes will need to be streamlined & the software rewritten to cut down on a lot of the bulky information.

In laymen's term, how does the simulation actually work?

DontAskMeAboutToday

We start with a MRI scan of the patient's heart, on which scarring on the heart caused by disease is visible. Using the scan, we reconstruct a geometrical model of the patient's heart, incorporating the scarring. The model is like a scaffolding, which we populate with "virtual cells" on the computer. These cells can have either normal function, or abnormal function, depending on whether they are part of regions changed by disease. We then stress the model, by prodding it with small electrical stimuli to see what arrhythmias are created. These small electrical signals occur naturally in a living heart, but don't typically affect healthy hearts, but can send a diseased heart into electrical turbulence. We analyze all the potential arrhythmias and devise the best way to ablate the tissue to stop them.

I also summarized this in my Ted Talk:[[https://www.youtube.com/watch?v=wSDMPxGGy3A]