Bioelectronic Medicine

Imagining the Future of Medicine

Christopher J Czura

The Feinstein Institute for Medical Research, Manhasset, NY, United States of America

Christopher J. Czura, PhD, is Vice President of the Feinstein Institute for Medical Research, Executive Publisher of the Feinstein Institute Press's international, peer-reviewed journals, *Molecular Medicine* and *Bioelectronic Medicine*, and Executive Producer of the Merinoff Conference Series. A pioneer in the emerging field of bioelectronic medicine, Dr. Czura's primary work in this field led to the discovery of the "neural tourniquet," a field of technology that uses electrical nerve stimulation to control surgical and traumatic hemorrhage. Dr. Czura's current research focuses on the molecular mechanisms of the neural tourniquet, and the development of new devices to activate this novel mechanism to control bleeding. Dr. Czura received his B.S. in biotechnology from William Paterson University in 1996 and a doctoral degree in molecular microbiology from Stony Brook University in 2009. He is author of approximately 80 peer-reviewed publications, book chapters and abstracts, and coinventor on a patent to control hemorrhage via vagus nerve stimulation.

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As scientists, we are usually too busy asking concrete questions to spend much time considering how today's discoveries will shape the world in the decades and centuries to come. But when, on rare occasions, science progresses at a breakneck pace, we'd do well to remember what Albert Einstein said about imagination being a greater resource than knowledge: the latter, the most preeminent genius of our era quipped, is limited to all we now know and understand, while imagination embraces the entire world, and all there ever will be to know and understand. In other words, to see the entire world more clearly, sometimes we have to imagine.

Imagine, then, a man waking up in the year 2025. He is middle-aged, fit and in reasonable health, but an alert pops up on his phone—or, better yet, on some piece of wearable technology, such as a watch or a pair of smart glasses—telling him that some trouble may be brewing and that his immune system is mounting an attack against a specific infectious threat.

Before you dismiss this scenario as science fiction, consider for a moment how close we already are to it today. In recent years, advances in bioelectronic medicine have allowed for electronic nerve stimulators to successfully curb disease by using the nervous system to intercept and override the communications the body sends to the immune system. Admittedly, we still have a long way to go, but now that we are beginning to understand the body's transmissions and how to affect them, it is not too difficult to think up a world in which bioelectronic medicine plays a much more sizable role.

This brings us back to our hypothetical patient: while our focus now, at this very early stage of research, is on curing disease, it is reasonable to hypothesize that we will soon apply the same understanding toward diagnostic purposes as well. If we can properly analyze the electronic data the body circulates, physicians of the future may be able to learn of abnormalities and risks before their patients are conscious of them. For example, think of a car issuing an alarm when the fuel level begins to run low, or when the oxygen sensor detects a rich engine mixture due to a clogged injector. When receiving an alert that something is "off" before overt symptoms set in, the next step would be for our futuristic patient to go see his doctor.

That process, too, would likely be radically changed in a future informed by bioelectronic medicine. Having access to both the patient's and the physician's calendars, automatic algorithms could set up appointments without a single phone call being made. And rather than waste time on stumbling around in search of a proper diagnosis, doctors will receive detailed data from the devices tracking the neural transmissions of their patients' own bodies. This process makes the experience of going to the doctor asynchronous: if a doctor were to have such specific and precise data delivered to her computer terminal, she would

Address correspondence to *Christopher J Czura, The Feinstein Institute for Medical Research, 350 Community Drive, Manhasset, NY 11030. Phone: 516-562-2110; Fax: 516-562-2356; E-mail: cczura@nshs.edu.*
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need not waste time with meeting patients, but could just as well schedule a video conference, explain the condition at hand and deliver the appropriate medicine.

And if medicine makes you think about a trip to the pharmacy, think again. Technology developed at the Feinstein Institute, for example, and already implemented in patients in several European countries allows physicians to administer electric signals instead of drugs to treat rheumatoid arthritis, with no known side effects and no need for pills, injections or other impositions. The physician of the future, then, could just as well end her teleconference with her patient by pressing a button that transmits the correct signals to the patient's nervous system, issuing the pulsating orders that will help the patient's body cure itself. With that, a new class of healers is likely to rise, consisting of trained professionals that are some hybrid of nurse practitioners and massive diagnostic databases, such as WebMD.

This is a vision of the future that I, as a scientist working in the bioelectronic field, am thrilled to try and imagine, and even more thrilled to work to make a reality. But it is not without its challenges. Being able to read more of the body's transmissions and alter them to avoid inflammation and other crises alters not only the way we practice medicine, but also our understanding of the seminal question that has occupied thinkers, poets and priests for centuries: that of the mind-body divide. A host of ethical questions arise. Imagine, for example, that we are suddenly able to prevent heart diseases merely by pressing a button; would that then excuse the behavior of anyone choosing to go out and load up on butter, beef and lard, knowing that any heart attack is preventable just by sending a few coded dispatches? In other words, will this technology create a moral hazard? Will we abandon our self-control the more advanced our medical technologies become? And by overriding the body's machinations in such an elemental way, are we not also interfering with the very notion of "self"—the key building block at the heart of so much of modernity? And what if the same button that cured arthritis could also affect moods, behaviors, perceptions—would we still press it then?

Other less theoretical questions abide as well. With so much data suddenly available to us, and with so much of it being so highly sensitive, we would need to find ways to store, protect, transmit and analyze it safely and securely, lest hackers infiltrate not only our information but also our bodies and nerves. These challenges are formidable, and they lie outside the scope of science alone. To ensure that the promise of bioelectronic medicine is fulfilled and that our immediate future is as stunningly bright as we believe it can be, a host of other professionals—technologists, engineers, data scientists, philosophers and others—would have to partake in the endeavor and help those of us toiling in labs and operating rooms define the boundaries and the breakthroughs of tomorrow. A good place to begin is by imagining what that tomorrow might look like. Below are brief answers from a handful of leading thinkers in various fields we asked to comment on this vision. They are diverse in their outlooks and approaches, but all display just the kind of robust engagement necessary. We hope that this journal will be a platform for just such discussions in the years to come.

DISCLOSURE

The author declares that he has no competing interests as defined by *Bioelectronic Medicine*, or other interests that might be perceived to influence the results and discussion reported in this paper.

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