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Short Communication

Electroceuticals in medicine – The brave new future

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A B S T R A C T

Electroceuticals are a new category of therapeutic agents which act by targeting the neural circuits of organs. The therapy involves mapping the neural circuitry and delivering neural impulses to these specific targets. The impulse is administered via an implantable device. In cardiology besides pacemaker, defibrillation and resynchronization applications it could have usefulness in heart failure, atrial fibrillation, coronary artery disease, myocarditis, resistant hypertension, atrial and ventricular tachyarrhythmias, pulseless electrical activity, and refractory angina.

Imagine no drugs
I wonder if you can
No need for surgeries or intervention
A brotherhood of electroceuticals
Imagine all the devices
Sharing all the world. . .

1. Introduction

Currently drugs rule the roost. Whatever cannot be treated by drugs is treated by interventions or surgery. Technically, all organs and functions are regulated through brain and nervous system; a circuits of neurons communicating through neural impulses. Even endocrine system is under control of central nervous system by a complex array of feed-back mechanisms. Furthermore, most drugs effect by either acting on final-receptors (neural) or endocrine mechanisms. But all known drugs and of-course surgeries or non-surgical interventions have definite side-effects, because their action cannot be exactly localized to the defective part or organ. In this context, imagine a day when instead of drugs, electrical impulses become the mainstay of medical therapy. Thus, instead of administering drugs, or doing complex procedures, the physicians may just administer electroceuticals which will target individual nerve fibres or specific brain circuits and be able to treat any condition.[1] In other words, the neural impulses that control the body will be entrained to regain the lost function and reestablish a healthy balance. Thus they could regulate a host of bodily activities; food intake, cardiac activity, pancreatic activity, liver, kidney or spleen functions. They could even control inflammation and set right many pathologies like diabetes mellitus, obesity, hypertension, heart failure, cerebro-vascular and pulmonary diseases. It is estimated that electroceuticals will become a mainstay of medical treatment over the next two decades, benefiting up to 2 billion people – a quarter of the global population – who are suffering from chronic diseases.

2. Definition

Electroceuticals is a recently coined term for an old therapeutic modality that broadly encompasses all bioelectronic medicine. It incluses any type of electrical stimulation to affect and modify functions of the body; neural implants such as cochlear implants, retinal implants or spinal cord stimulators for pain relief but also cardiac pacemakers and implantable defibrillators. Recently, the field has expanded to include deep brain stimulation and the electrical stimulation of the vagus nerve. Also called bioelectronics, the idea is that tiny electronic implants will be able to treat a vast range of chronic diseases, such as diabetes, asthma, chronic obstructive airway, arthritis, hypertension and other heart ailments and gastrointestinal diseases.

3. Mechanism of electroceuticals action

Since the key target of electroceuticals is neural circuit, the first perspicuous step towards development of this therapy is to precisely map the neural circuits associated with disease and consequently its treatment. This involves two levels:

1. Anatomical – nerves and brain areas associated with disease are identified so as to clearly define the anatomic site of intervention.

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Fig. 1. Electroceutical circuit.

2. Signalling – exact electrical signal/action potential or patterns associated with health need to be identified, so that these patterns could be replicated.

Subsequently, in diseased states, individual electrical impulses and patterns will need to be identified to elicit the most effective therapeutic response. Finally, electroceutical devices in the form of a cuff, bristling with electrodes, will need to be developed which can be attached to nerve bundles to alter the electrical signals sent to brain on one hand or bodily organs on the other (Fig. 1). These devices might use microchip-controlled electrode arrays and may be powered by electromagnetic energy (heat, light, magnetic), mechanical or even chemical energy harvested from body's resources. First generation of these devices were available in size of a pill or a pen, but with current technology they have reached the size of a pin-head. However, the future will be micro- or even nanoscale devices.[2]

Simply put, the concept is to first map the nervous system and understand which nerves control which functions and then develop an implantable device to control this function. In diseased states it is a matter of rewiring the body if signals go awry, a kind of volume control (like a radio) on a nerve; by changing the volume of the signals (using the device) it may be possible to control the organ. Any endocrine organ may be controlled this way; islets of Langerhans stimulated to produce more insulin at the time of meal ingestion or dilatation of airways during episodes of asthmatic attacks, just far more precise than the conventional drugs, with a real potential to optimize and personalize the therapy but at the same time with far less side-effects.

4. How are electroceuticals different from conventional drugs?

Therapeutically, electroceuticals score over conventional drugs in a number of ways. Number one, they target neural electrical circuits which are composed of discrete elements; a system of – interconnected cells, nerve fibre network and nerve bundles, thus allowing for precise application of therapeutic effort. The final common pathway of this whole circuit is generation of action potential which itself can be modified allowing for additional control. Thus overall, efficacy increases but side effects decrease because of extreme specificity of response.

5. Electroceuticals in cardiology

Electroceuticals have long been used in the area of cardiology. The first implantable pacemaker was placed into a 43-year-old man suffering from cardiac arrhythmia syndrome in 1958, and the patient went on to outlive his surgeon, Dr Ake Senning from the Karolinska Institute in Stockholm.[3] Later cardiac defibrillators were developed and then cardiac resynchrization devices. However, recently vagus nerve has become a focus of interest. Vagus nerve stimulation or vagal nerve stimulation (VNS) is a medical treatment that involves delivering electrical impulses to the vagus nerve. Since the vagus nerve is associated with many different functions and brain regions, research is being done to determine its usefulness in treating a host of diseases; various psychiatric disorders and addictions, neurological disorders, multiple sclerosis, etc. However, in the field of cardiology it has been evaluated in heart failure, atrial fibrillation, coronary artery disease and myocarditis.[4,5] Likewise, carotid baro-receptor stimulation has been used for resistant hypertension.[6] In area of electrophysiology there will be numerous applications; low-energy multistage electrotherapy for atrial and ventricular tachyarrhythmias, medium-voltage electric therapy for pulseless electrical activity, spinal cord stimulation for refractory angina, and contractility enhancement via cardiac contractility modulation devices.[7]

6. Limitations of electroceuticals

1. The neural network is too complex to be completely mapped and it remains a challenge to durably, reliably, and non-disruptively address a enormous number of individual neurons, and neural information flowing through these circuits.
2. There is a possibility that the impulses targeted to a specific nerve group may also stimulate the surrounding nerves.

Conflicts of interest

The author has none to declare.

References

1. Famm K, Litt B, Tracey KJ, Boyden ES, Slaoui M. Drug discovery: a jump-start for electroceuticals. *Nature.* 2013;496(7444):159–161.
2. Mishra S. Nanotechnology in medicine. *Indian Heart J.* 2016;68:437–439.
3. Aquilina O. A brief history of cardiac pacing. *Images Paediatric Cardiol.* 2006;8(2):17–81.
4. Gold MR, Van Veldhuisen DJ, Hauptman PJ, et al. Vagus nerve stimulation for the treatment of heart failure: the INOVATE-HF trial. *J Am Coll Cardiol.* 2016;68:149–158.
5. Vagus Nerve Stimulation. https://en.wikipedia.org/wiki/Vagus_nerve_stimulation.
6. Zhang J, Zhou S, Xu G. Carotid baroreceptor stimulation: a potential solution for resistant hypertension. *Interv Neurol.* 2014;2(3):118–122.
7. Lau C-P, Siu C-W, Tse H-F. Future of implantable devices for cardiac rhythm management. *Circulation.* 2014;129:811–822.