JOURNAL OF BIOELECTRICITY, 2(1), 77-81 (1983)

SHORT COMMUNICATION

THE ROLE OF THE ORTHOPAEDIC SURGEON IN THE DEVELOPMENT OF BIOELECTRICITY*

R. O. Becker, M.D.
Erie Canal Road
Star Route
Lowville, NY 13367

It is an honor and a pleasure to be invited to speak to you on the occasion of the 50th Anniversary of your organization, the American Academy of Orthopaedic Surgery. Certainly you have a lot to be proud of; the record of the AAOS in establishing the present levels of education and practice is well known. However, there is another accomplishment that I believe overshadows all the others, one that I am sure the great majority of you are unaware of.

As orthopaedic surgeons we tend to think very provincially, with our specialty being the most important aspect of our intellectual life. As a result, the recent use of electrical currents and electromagnetic fields for the stimulation of bone growth has been assumed to be a relatively minor phenomenon, based upon the piezoelectric property unique to bone, and of no greater import. The truth is far more than this. What has actually happened is a complete revolution in the basic concepts of biology. What may result is a revolution in medical practice in many areas far removed from orthopaedic surgery.

---

*President's Guest Address, March 11, 1983, American Academy of Orthopedic Surgeons 50th Annual Meeting, Anaheim, California.

 0730-823X/83/0201-0077$3.50/0

I should like to take a few minutes of your time to review this important development and to indicate the central role played by our specialty. The story goes back to the late 1700's when Galvani thought he had identified electricity as the "vital spirit", that imponderable something postulated by many great thinkers since Hippocrates that gave life to the organism. The conflict between the vitalists, who proposed this idea, and the mechanists who believed that living things were simply more complex assemblages of non-living units had been going on for a long time. Galvani's claims only renewed the debate, but now the mechanists had a target — electricity. All that was necessary to destroy the vitalist concept was to eliminate electricity from the study of living things. A period of great scientific activity ensued. Galvani was soon proven wrong by Volta who showed that what Galvani had observed was really the generation of a new kind of electricity — direct current — by the junction between two different metals in a conducting solution. Volta's work was the basis for the storage battery and actually set the stage for much of the technological world we are all familiar with. Fifty years later, Matteucci showed that Galvani was not all wrong, living things did generate electrical currents, particularly at sites where they had been injured, the current of injury. But by now the tide was running strong in favor of the mechanists and little attention was paid to Matteucci. Discovery followed discovery and by the beginning of the present century science was firm in its mechanistic view that living things were merely chance aggregates of complex chemical structure. Biochemistry and physiology would soon be able to explain all the functions of living things and none of them would have anything to do with electricity.

It became apparent that the chemical concept did not explain everything; there were many basic biological functions that remained total mysteries. These included growth and development to name only a few. In 1941 Dr. Albert Szent Gyorgyi, a former Nobel prize winner, gave an important presentation in which he indicated these defects and proposed that the

enormously complex yet highly organized structure of biological molecules have made electronic conduction possible. By this he meant semiconduction and other solid-state electronic mechanisms such as piezoelectricity. He proposed that living organisms generated and transmitted small currents in this fashion and that these regulated life processes by influencing cell behavior. Nothing was done, organized science reacted with complete indifference, even Nobel prize winners are ignored when they say something that changes present dogma.

Nothing would have been done except for a few curious orthopaedic surgeons. In 1953, Dr. Yasuda not only demonstrated piezoelectric properties in bone, but he also showed that applied electrical current could stimulate bone growth. In 1960, I presented evidence at the AAOS meeting in Miami that the current of injury in animals that regenerated was much different from that in animals that lacked that capacity. By 1962, Andy Bassett and I rediscovered Yasuda's piezoelectric effect in bone and in 1964 we confirmed his observation of the electrical stimulation of bone growth. In 1966, Bert Friedenberg and Carl Brighton were studying the electrical events associated with fracture healing and in 1972 they reported the first clinical application of this method.

What has happened since then in orthopaedics is, I am sure, well known to all of you. The technique of electrical or electromagnetic osteogenesis has become an accepted part of the orthopaedists's clinical armamentarium for the treatment of non-union. However, that is probably the least important event in the cascade of discoveries made since 1960.

The scientific establishment views all clinicians as fairly stupid with orthopaedic surgeons being particularly so. So when these crude fellows began to experiment with electricity in biology, and particularly when they committed the heresy of actually using electrical currents to stimulate growth clinically, something had to be done! We had to be proven wrong and the dogma had to be defended. Many experiments were set up and run with the firm expectation that living things were going to work exactly

as the dogma predicted. What happened was that more and more of the members of the establishment came to say the same things that we did. In addition, by the end of the 1970's no one could really questions the results of the clinical applications; here was something real and if the dogma had to be revised, so be it. In 1960 the scientific literature contained a bare handful of papers of the effects of small currents or fields on living things, in the last 6 months of 1982 there were more than 7000 citations in this area.

We now know the following:

> All living things are closely tied to the electromagnetic fields of the environment, and very probable changes in these fields were involved in the origin and the subsequent evolutionary development of life.
>
> The central nervous system functions at the most basic level in the fashion envisioned by Szent Gyorgyi, generating and transmitting minute currents which regulate growth and healing and establish the basic level of the neural functioning.
>
> This activity results in the generation of the recently discovered magneto-encephalogram, a magnetic field extending out in space from the brain and relatable to basic mental activity.
>
> Many species of organisms, including the higher primates and man, have been found to have actual deposits of magnetic mineral within the central nervous systems, the functions of which are just now being evaluated.
>
> Levels of electrical currents far below those that are perceptable are known to profoundly alter behavior and cognitive functions as well as to influence cellular growth and regeneration.
>
> Changing magnetic fields have been shown to alter mitotic activity in mammalian cells.
>
> Abnormal electromagnetic fields produced by man's activities in power generation and transmission and in communications have been shown to have biological effects and this area is being actively explored at this time to determine the extent of the associated health risk.

You can see that biology is in a state of rapid transition and that what will result will be a very different view of how living things work. This change would never have occurred if it had not been for the effort, curiosity and willingness to disregard dogma on the part of the orthopaedic community. The record of the past 25 years is one that all orthopaedic

surgeons share in, clinician and researcher alike, and one that we can all be justly proud of.

In a short review such as this, one can mention only a few of the people who made contributions. Many others made equally important contributions, their omission from mention was dictated by time constraints.