Can Functional Electrical Stimulation Restore Function?

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00:03 OK so we’re going to talk about Can functional electrical stimulation restore function? And we talked about this a little bit yesterday when I was here and I don’t think anybody was there when to recap a couple of things and then we’re going to go a little bit more into the data. All right. So briefly what is functional electrical stimulation? You may remember that to said the F stands for Functional, ES Electrical Stimulation. What that means in our clinics we use we find a weak muscle. And we find electrodes that we put over those muscles there’s little sticky pads. Essentially, they’re connected with cables to a tiny little box which is the Neuromuscular electrical stimulation NMES unit. Let me turn this on and then you can essentially induce a contraction in that muscle. So, if I have done this on my arm here you can sort of bring the wrist up where I can put it on the deltoid and bring your arm up or we can do that on the legs on the quads and straighten out the legs and each person needs just a little bit different amounts of Electro stimulation and devices that come that provide this innumerous always a FES comes in all kinds of sizes and shapes.

01:20 So traditionally if you go back into like in 1980 or the 1990s most of these systems were implantable. So, we had wires directly underneath the skin electrodes that were wired straight into the muscles to restore some of the function that we were thinking was very important mostly in traumatic spinal cord injury. So, the most famous one came from Germany was called a “Freehand System” which helped restore some movement in the in the hand.

01:51 There was a “Vocare System” to help restore bladder function. Diaphragmatic Pacers have been out for a long time meaning stimulating diaphragm that helps with breathing. And then we got the external devices which are mostly using he and the United States is you know the sticky pads that we have on the outside. There are little handheld units. We have to use electrical stimulation bicycles. You’ve seen one outsides presented by the Restorative Therapy group. There is a European competitor to that that I didn’t see him today. It’s only two people or two vendors who are who provide to us. And then we have what’s mostly known in multiple sclerosis foot drop braces.

02:35 So bracers instead of using plastic to keep a foot up you can use functional stimulation braces for your ankles. Well we’re going to talk about a bit more. The problem was with the implantable systems they looked all very good. And then there was lots of hardware failures. So, the wires broke electrodes got lost
and we couldn't fix them. So, the field had sort of moved away from the use of functional electrical stimulation implantable devices to go back to Europe right now especially to the UK. There are a lot of new implantable devices back in clinical trials. So, we I'm sure we're going to see some of them here in United States as well.

03:14 Alright.

03:15 This is the kind of this simple version of electrical stimulation bicycle. Essentially if people who haven't seen it yet if you can sit on that bike and you can get electrodes connected on the outside to your quadriceps muscles to hamstrings and glutes. That's kind of the simplest set up on both sides. And then the computer can turn on these electrodes and can sort of start moving these muscles in the right sequence. So, you're right that bicycle on your own muscle power that's essentially very huge for people who have no voluntary function in their legs because now you can actually provide an exercise which was essentially impossible for you before. You get all the benefits of exercise. And so that means you build muscle mass you decrease your risk of diabetes and heart attacks. Now we help with the cholesterol you put stress on your bones to decrease the risk of fractures, skin breakdown and then infections.

04:15 So very interesting device. Very powerful unfortunately also very expensive. So, insurances, the commercial insurance is pick it up from time to time usually do. Medicare Medicaid generally does not. So, there's a lot of fund raising usually going on in those families. So why are we doing this. We're going to it's going to bring us back to Jaime's talk. We know that spontaneous regeneration occurs in our spinal cords and brains at all times. I said yesterday while we're sitting here we are making tons of new cells. Does anybody remember what cells me were trying to make? What's in the tool kit for repair? Everybody's asleep already. So, these are the big ones. So, the cables of the nervous system are called in neurons right.

05:08 This is one cell has a long arm reach us out tries to connect it with the next cell and then each one of these cables because you bunch millions of them together in your spinal cord and in your brain, has to be insulated. Right. That insulation is made by the body. It's called the myelin and is made by the oligodendrocytes. It's the cell you see on the bottom left there's a little star shaped one. And then we have the astrocytes who are right in between. These are the guys who kind of provides a structure to provide nutrition. And so, we need all three of them to you know to do their job. So, to see whether or not FES works. We designed an animal model for rats essentially where we use an implantable FES device because animals are not so easy of putting electrode stickers on them and make them move.
So with those little rats we had to create it first. We gave him a traumatic spinal cord injury because we wanted to make sure we have a very clear place where the lesion is going to be. Essentially, it's simulating like we have in TM one lesion usually in the spinal cord. That's kind of what we set in these animals. And then we wired these electrodes underneath the skin to the to the paws, the hind limb paws usually for the foot elevators and the picture of the device is on the top right. You see it's kind of small has three wires attached to it and it's a see-through device. So, it has a little light sensor and as anybody or still remember with the timing light is?

Some men still nodding like you used it in a car to kind of program a program part of that car is almost like a pretty powerful flashlight. So, what you can could do we could turn this device on or off through the skin of the rat and make it make it move and not without a cage. It's kind of funny that it was a gun and kind of shooting at it and the end to end and the rat started it started moving.

You didn't say dance.

So and then be looked at is we counted the numbers of stem cells in the I think up my old talk.

We looked at a number of stem cells in the in the data.

So this is a graph that plots on the bottom the levels of the spinal cord. So, “C” stands for cervical So it's right up here then “T” is thoracic spinal cord around here. “L” is the lumbar spine and then on the Y-axis you see the number of cells that were born because we found a way that we could label newly born cells that kind of gives us an idea how many actually born within a five-day timeframe. You see that the animals and let's just look at the blue columns for now you see as we get closer to the injury level which is kind of in the center between like T7 and 11. You see there were more and more cells born to what's the epicenter of the injury. And then you went off you see that is some cell birth really dropped off traumatically.

As you get for way distally to the lesion, meaning below the level, and that kind of showed us is you remember yesterday when I said that activity is extremely important for these cells to maintain function. So now if you disrupt activity meaning the signal can't travel from the brain past the injury side to the bottom of it that the system really has difficulty to maintain. So, the amount of stem cells born dropped off dramatically at this at those levels and then the yellow graphs show the animals that actually received the electrical stimulation three times three times a day seven days a week in these labs. And you see that you can actually increase or normalize the number of cells born in those levels you
see in their bottom like L1 and L5. So now we can show that you give FES you can actually replace cells.

09:19 The next question always is, “What are these cells?” You know at least the scientists in a room have that question very commonly. Some of what we looked at the cells you know the first one was on top left the astrocytes the support side type of cells and compared it to is there a difference above the injury versus below the injury where we stimulated. And that was not the kind of looked exactly the same. The blue and the yellow looked about the same height. Then we looked at the cells that were sort of a late stage stem cell. So, it was a stem cell that was able to become an astrocyte, an oligodendrocyte. And you see there's a little bit of a trench that meant that maybe a couple more so in the in the area where we stimulated.

10:04 But it was still not. No difference. We saw a big difference when we looked at the true stem cells in that in that system. So, these are as Nestin positive cells these were cells that could technically become a neuron or an astrocyte or an oligodendrocyte. And you see that over all their cell birth is dramatically decreased in their natural state. And as soon as you have increased activity again in that spinal cord you can normalize or get a close normal. The number of cells born. So now we know that it that we can restore cells. What else can we restore. Because the topic was pretty broad. I me ask can restore function. So, if you look at this the most common one of the oldest uses of FES was restoring breathing.

10:57 So you will see sometimes there are levels involved in the spinal cord that really make it difficult for the person to breathe on their own. So, they are on a ventilator or need assisted devices at nighttime like C-PAP devices so they can actually inflate their lungs. So, it has been phrenic nerve stimulation which is the nerve that travels from you from your brain and goes to the diaphragm. You can put electrodes right around it and stimulate that one or if that doesn't really work you can actually put needles needle electrodes straight into the diaphragm itself and can power it. So that gives us the opportunity for some people and we have done it in a couple of children in the past to actually regain breathing essentially on your own without the ventilator. So that's one way of restoring breathing function with FES.

11:48 So now we know we can restore cells we can restore breathing. The other thing bowel bladder sexual function very big one. I was surprised when Ben presented at the CAPTURE data that's only a small fraction of kids actually has bowel bladder dysfunction. Generally, I see a little bit more in my clinic especially in the adult population. Almost everyone with spinal cord disorder has a has a bladder dysfunction although it is always the fun discussion and clinic and I say, “So any problems about bladder function?” They said, “Nope”. I said always look
at the spinal cord and said, “You should have something” and then they say, “as long as I go six times a night is perfectly fine”. And I said, “Well, that's not normal, right?” And so sometimes you have to critically ask that question the same thing nobody did. People generally don't bring that up that the bladder isn't running right or that they have sexual dysfunction. Usually it's the spouses it's that, “Hey, come on. Tell them.”

12:50 And so it becomes a fun visit. So, there is there is actually some help available for trying to restore some of the bladder bowel and sexual function. Usually by the use of sacral nerve stimulators. So, this is another implantable device and that goes underneath the skin and stimulates just the bottom roots of your nerves as they come out of the spinal column. And with that you can actually restore some contraction in the bladder and you can restore some in some ways of starting initiation of it of a bowel movement. It can help with sexual dysfunction so it can help with erections and ejaculations. The problem with the current devices on the market for sacral stimulators is they're still not MRI safe. So, if he moves that if he if he go that route be careful because he may not be able to have another MRI.

13:47 So I don't like that a whole lot. In our conditions because MRI is a very valuable tool to try not to give up. But hopefully the that the makers of these devices will come up with but the fix to that in your future. OK. You can repair cells they can repair we can restore breathing we can do bowel bladder sexual dysfunction. So then hand function very very important to most people can you use FES to actually restore grasp. And the short answer is yes, it is a picture of a brace that's available in United States. It's called the “BioNess” that brace exists for the wrist but it also exists for a foot drop. I’m going to have another picture of a foot drop in a second. Essentially as you see it kind of wraps around it has little paddles of electrodes that go right onto the muscles and you can actually train this device together with a patient and a good occupational therapist to restore a grasp in some people.

14:49 Problem with this is insurance is very reluctant to pay for that. And B there are not very many sizes available. So, if you're not the average person it's a little trickier to get this to work. All right this is a picture of the foot drop brace. So, treating foot drop we talked about you can use ankle foot orthosis. Which is all plasticky thing is and it could be very clunky like the old ones that you might still know, like from the childhood days. Then you get the really fancy ones out of carbon fiber that you know you can barely see that almost fit in a sock.

15:29 And then what I like for my patients if it's possible to use one of those braces because this is essentially functional to a stimulation for everyday use. And you don't have to think about. Do I have to go now? In my exercise room and start training. I mean talked about yesterday I said you know three to five times a
week at least this is the thing you got to put on every day and you can also take off. Ok done exercise today. And it makes it makes it a little bit better. Well independence for walking. It has been a lot investigated in multiple sclerosis and in clinical trials so there's actually insurances that are more likely to pay for this. There's a competitor on the market which is called “WalkAid”. It works very similar.

16:15 How does it work. I’d like to show it but I’m connected to this microphone. There’s a there’s a sensor in in the foot. So essentially when you move your foot forward and lift your heel up that means that your foot has to be elevated. So now the brace turns on. So, it turns it on your foot lifts up you at some point it has to let go because otherwise you’d be walking on your heels the whole time. So, as you move your foot forward and set it back on the ground the sensor triggers and turns to brace off. And now the foot goes down now does same thing happen with the other foot. Now you lift up your foot sensor turns on foot goes up foot goes forward you put it back down goes down. So, it works actually quite well.

16:56 This is not something you can just simply buy. You have to get evaluated in a physical therapy setting. There are actually centers that are specializing in or they’re certified by BioNess to do they the fitting. Cost us about six to seven thousand dollars per leg. So quite quite pricey. And then I think the most exciting one that data that we had done of do use a function electrical stimulation in multiple sclerosis was published in 2015 and I hinted at this yesterday already at the at the talk we show the natural progression of MS as depicted in the blue line. You see that you start at 100 percent and you may have a relapse you come back a little bit, probably close to normal and have another relapse and things over also have start trending down.

17:53 And at some point, really, it's mostly a downward progression with the initiation of an activity based therapy program with the use of functional electrical stimulation. We’re able to show that people have a 75 percent chance of not worsening over the next two years which is essentially keeps you sort of flat on this line. And you know for the outside person that means oh my God you know doing anything you know changing what are we doing this. But if you consider that the natural history is going down you can essentially be gaining all this stuff in between these two these two curves. And there's a 25 percent chance of actually giving people function back that meant strength sensation mostly and with that mobility.

18:41 All right. So now in summary we kind of shown it now.
18:45 You can FES restore function? Yes. And the short answer always should be the neurology answer. So, if you ask the neurologist What does he say if he get the right question the right and wrong just always answer is it depends.

18:59 You know so.

19:02 But here we have lots of depends you know depends on what you are looking for. You know do you want to restore breathing function as you can. Or do you want to restore movement to the legs. Yes, you can. So, there's almost. So, FES has a lot of different applications that you can take you will take advantage off and you should. So, ask your neurologist. Ask you physical therapist your occupational therapist and let them give you this technology and keep exercising.