THE SIXTH INTERNATIONAL SYMPOSIUM ON EXTERNAL CONTROL OF HUMAN EXTREMETIES

August 28 - September 1, 1978
Dubrovnik, Jugoslavia.

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- FUNCTIONAL ELECTROSTIMULATION BY ELECTRODE IMPLANTATION IN ANIMALS.-

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SUMMARY

To study the longterm effects of functional electrostimulation with a wireless implanted stimulator, an animal study was set up.
In this experiment the femoral nerve of the cat is stimulated.
During this stimulation period there is a control of the e.m.g. of the stimulated muscle, a registration of the threshold value of the administered pulses and a measuring of the contractibility of the stimulated muscle.
Afterwards there will be a pathologic-anatomic study of the nerve and muscle in order to look at the changes, which may appear.
In this paper the method will be explained and the preliminary results will be presented.

-FUNCTIONAL ELECTRO STIMULATION BY ELECTRODE IMPLANTATION IN ANIMALS-

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During a number of years, the Rehabilitation Department of the Free University Hospital in Amsterdam, is studiing Functional Electrostimulation.
In the beginning this was restricted to the experimental work with the peroneal stimulator. Today this apparatus is normally used in clinical circumstances.
A great experience was built up with the conventional type of stimulator, the Yugoslavian FEPA 10, which is equipped with surface electrodes.
By frequent use of surface stimulating we met difficulties in many patients in finding the right position of the electrodes, and problems with broken wires or other technical troubles.
Other investigators had the same problems, so an implantable, wireless stimulator was designed. In experiments these have been used with succes. Some of them are already available as a commercial product. The purpose of this paper is to give a brief report of the research in this field,at this moment,in our Rehabilitation Department.
Early experiments with rabbits, stimulated with an implanted electrode and a skin plug connection to the stimulator showed that the use of implanted electrodes in electrostimulation could occur without damaging the nerve, but also that a wireless system should by far be preferable.
An investigation was set up to study the longterm effects of electrical stimulation by an implanted radio frequency steared and powered system.
The basic design for such a stimulator to be used in animal trials had been developed by the engineers of the Rancho Los Amigos Hospital in Los Angeles.
For this experiment, which is still going on, the femoral nerve of the cat is stimulated by an implanted stimulator.
During the operation we take special care to prevent damage to the nerve. The electrode is placed around it, as proximal as possible in the groin.

The electrode cable with the connector will subcutaneously be tunneled to the backside of the animal.
At the backside a pocket is created in which the plug from the electrode will be pulled and connected with the in this pocket positioned stimulator-receiver. After closing the wound the stimulator is tested and thresholdvalues are determined.
Finally a muscle biopsy is taken from the quadriceps muscle in order to compare it with the biopsy taken after the experiment.
The electrodes are made of two stainless steel coils, put in a silastic cover. A piece of dacron is attached to the electrode head in order to promote the fixation in the surrounding by the ingrow of connective tissue.
The stimulator reciever measures 6 x 6 x 2,5 cm. and has a weight of approximately 80 gr. The electronic parts are placed in epoxy.
The radio-frequency signals which the receiver picks up from the cage atenna are used, as well for the power supply as for the code of the stimulus.
The transmitter that is generating the radio-frequency signals is equipped with an antenna, constructed round the cage in such a way that the transmittered electric field will be unchanged where ever the cat may be in its cage. Therefore the stimulus given to the cat will always be of constant value.
A portable antenna, can be used to stimulate the cat when it is outside the cage (for example when testing the system on the operation table.
The transmitter has the following specifications:

puls intensity	:	maximal 5 mAmps, adjustable in steps of 50 micro
puls width	:	adjustable from 100-990 microseconds.
frequency	:	fixed from 1-100 Htz sweeped from the fixed frequency till an end frequency of 100 Htz.
stimulus duration	:	maximal 99 seconds.
stimulus interval	:	10 - 109 seconds.

The animals are stimulated 2 hours a day with a stimulus of 2 seconds twice a minute.
Pulswidth and amplitude are regulated in such a way that the stimulus excitates a normal contraction of about half the maximum strenght.

This sensitivity of the individual nerve is variable but the range for most of them is always between 200 and 400 micro Amps with an pulswidth of about 250 microseconds.
The frequency is 40 - 60 Htz (cycles/second.)
Several parameters are measured in order to get an impression of the function of the muscle-nerve unit and the possible damage.
In the first place:
- the e.m.g. of the activated muscle is registrated to look if there will be anabnormal e.m.g. pattern in course of time.

second:
- Threshold amplitudeforevery pulswidth is determined.

third:
- with aid of strain gauges the excitated contraction is registrated so that some of the contractile characteristics can be examined, namely: contraction force, contraction velocity and relaxation time.

These three parameters are measured during the experiment every 3 weeks.
After a long period of stimulating the stimulated nerve will be taken out of the animal for pathologic-anatomic examination.
A second biopsy willbetaken from the quadriceps muscle to see if there have been changes in the muscle fiber pattern.
This experiment is not yet finished. The present results are obtained after only two months of stimulating. There are no changes in the registrated e.m.g. pattern until this moment.
Threshold amplitude of the puls is slowly increasing for about 3-4 weeks, but stabilizes after that period.
The function of the muscle remains good, no changes were found in the contraction parameters.
From two cats there are some autopsy findings.
One of them died by an intercurrent infection and the other was sacrified, because the nerve had slipped out of the electrode head which was not closed in the right way.
Muscle biopsy showed no abnormality neither did the microscopic study of the nerve. But the stimulating period was probably too short for changes. Research on the long term effects will be continued.

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