ABSTRACT OF PAPER FOR CONFERENCE IN OPATIJA

YUGOSLAVIA

Myo-electric control of muscle substitutes +

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Myo-electric control offers certain potential advantages, compared with orthodox mechanical control techniques. The method seeks to use as control signal the electrical activity which can be demonstrated to persist in the residual muscle in the stump (in the case of an amputee) or in the paralysed limb. This electrical activity is a measure of the amount of nervous stimulation of the muscle and therefore of the voluntary effort which is being made by the patient to contract his muscle.

Previous work on myo-electric control is surveyed briefly, and the current project at St. Thomas' Hospital (carried out in collaboration with Dr. A.B. Kinnier Wilson of the Polio Research Centre, West Hendon Hospital) is described. This is an investigation into the electrical activity of the upper arm muscles during flexion and extension, against known loads and under carefully controlled conditions, using small surface electrodes. So far the preliminary work has been done on normal subjects. The amplitude of the electromyogram (emg) is measured after rectification and smoothing with a time constant of 100 milliseconds. The emg increases with load in a given position, but the relationship varies from one subject to another and depends upon the particular muscle chosen. For a constant load the emg from the biceps group during flexion shows changes by a factor of 3 to 4 to 1 as the angle of flexion at the elbow is varies. The "cross-talk" from one muscle group to electrodes placed over the antagonist has been measured, and also the effect on the emg of altering the bandwidth of the amplifier. The emg is usually less during "let down" than in "pulling up". Experiments on movements at controlled speeds have shown little dependence on speed. These results are discussed in relation to the problem of using the emg as a control signal.

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MINUTES - continued Tuesday August 28 - morning session

WILSON: the 5 kgs/cm^2 of pressure.

LORD: I have laready done this with a chairpatient whom I have fitted with a plexus splint. Now,he pluge in the normal line in the factory. We have taken care of this in one case only. The patient has a cylinder shell too, and being a chaired case there is no problemin carrying the equipment. Whenhe arrives to the factory he pluge into the normal air line which has a reducer. Thus he sits down and Does his work not consuming hos own CO_2 until he leaves for his home. So we do this already.

Mr. WIENER: I was thinking that with a liquid gas something more could be done.

Mr. WILSON: Ye., I think we must watch both size and weigth in adding to our equipment, because we already provide an equivalent of the ~~equipment~~.

Mr. WIENER: All these means should be considered.

Mr. WILSON: Oh Yes.

CHAIRMAN: Any other questions please?

Mr. WOOLMER: I would like to ask Dr. Kinnier Wilson if he has considered some other materials for the construction of his apparatus. He said that he used nylon for power torques, I wonder if it would not be to any greater advantage to use the material in PTFE (polytetrachloroethylene) It has certain advantages because it is light, strong, and it is easily machined and it has a very low coefficient of friction.

Mr. WILSON: We have considered the use of PTFE which would be a cheaper way of doing but at present it is generally thought in the part of the pneumatics industry which deals in this that PTFE seals are better used not under sliding conditions. And so until we get a firm which is prepared to provide us with what is required, we cannot use plastic seals. It seems better to use ordinary construction methods for the cylinders. One way of doing it, which we hope to investigate but may well prove quite unable to stand up to the stresses involved over a long period,

are the use of plastic syringes. These of course are designed at the present moment to be used once and then thrown away but it may well be that they are placed inside of some form of a light container and may prove to be better than a strong inhabitated device of duralumin. We do not know yet. These are just methods of trial. At the present moment we know that this motor is reliable enough for chemical trial and what we do not know is how hard it will bebattered by the people who ar. using these devices. And it may well be that plastics simply do not have, with the exception of nylon, the ability to stand up to shock loading that metal has.

CHAIRMAN: Any other questions please?

SWETTENHAM: Could I perhaps add something on the experience we had with the velcro. Somebody was asking about it. It is most useful. We had tried it on the arm prosthesis and leg prosthesis but there are two points which should be borne in mind. Do not make an overlap on the flat surface. It will if it is on the flat. Make it on the or better still put the end in the metal tube as it has been d ne by the American prosthetics work. So that you got the loop pass around the but it is a very good stuff indeed.

Mr. BOITEN: I would like to say that I very much admire your solution. As fur as my engineer.ng experience goes I do not think that you would find better material for this purpose than duraluminium at the moment. With the regard to weight and stiffness I do not believe that for the designing and construction it would be an advantage to use plastics. On the other hand for the plunger itself the plastic would be of advantage and may be that there are at the moment nylon coverings which are loaded with MoS_2 part which also give a low coefficient of friction which is not very much different from the coefficient of friction of teflon as it is a dry lubricent and there is no need to oil it. So it is entirely clean. Thus, if you would like to improve in weight there might be possibilities to make this plunger of plastic material. But I do not think that it would be worthwhile to change your outside construction in

using the plastics as the material. I think you should stick to your dural. The only thing which from the mechanical point of view I did not like very much is, that you are using two cylinders under pressure, which means that the total forces in the system as a whole are much bigger than the output forces of the system. If you wish to construct something as light as possible you have to avoid large internal forces in the system. Therefore, I would like to know whether you have considered using rotational motor with a vane instead of this recti-linear motor. Thereby you obtain the rotational movement without the necessity of cables and so on. Have you considered the possibility of a rotating vane motor instead of this rectilinear motor?

Mr. WILSON: Well, yes. May I just briefly refer to your first remarks. We are at the moment using nylon pistons and not the duralumin pistons. We do also use which we normally used in an oil and now use in dry spray lubricant. It is still messy and I have one of my favourite shirts permanently spilt. But from carrying the valve box hanging down from my shoulder and demonstrating on my shoulders without covering it, to be able to show the people how it works. I am very glad to know of nylon impregnated and we shall certainly try and get some. It is for our purposes a very good lubricant, it is better than the other that we tried. Now, as regards the use of the rotating vane motor we have got one in the laboratory undergoing examination at the moment. The difficulty is that for splint work of course it must be bulky and it must stick out from the outside or inside the splint. The only one that we know which is commercially available is made of heavy material and of course we would have to redesign it. But clearly for the prosthetics work a vane type of motor may well be the answer to the problem, because it would fit into the joint or it would be in the other angle of the forearm and as you say it can be easily packed. And I hope that we shall have success with it and we will just see how it will go. We also considered the possibility ofusing high speed vain motors of the suitable

type with gearing and we are not very far with that. I think that the vane motor might be the possible solution in some instances, and if there are good vane motors in your country I shall be very grateful for any addresses that you might give me so that we might buy some and try.

Mr. BOITEN: I have to answer just the question you have put about the addresses. Unfortunately we have no commercially available vane motors. But I have a few students in the laboratory who are working on this type mainly for paralysed patients. Actually at the moment we are, contrary to you, using oil instead of air or gas. Our pressure is about 35/kgs/cm and that makes it possible to get relatively small vane motor which can be placed inside the system which transfers air pressure of about 7-8 atmospheres.

Mr. WILSON: Is this a gas driven hydraulic pump?

Mr. BOITEN: It is a gas driven hydraulic pump of the rectilinear type whichis very simple and which is not very expensive. It is lubricated automatically and we hope that it would be possible to obtain a rotating device sufficiently small and powerful to do the same sort of job.

Mr. WILSON: I am not an engineer so that I cannot say whether there is likely to be a great loss of efficiency in this transfer from gas to hydraulics.

Mr. BOITEN: 95%.

Mr. WILSON: 95%? It is very good then.

Mr. WIENER: If you are goind to transfer from gas to hydraulics you might as well use electric motors.

Mr. WILSON: Electric motors are heavy and electrically driven hydraulic compressors are usually very heavy. I do not know of any small one.

Mr. WIENER: No?

Mr. WILSON: Do you know one?

Mr. WIENER: I was just wondering what can be done with light electric motors with permanent magnets which are extremely small with the materials we have now and I think that this could be the explanation too.

Mr. WILSON: I am sure that they are coming along. I have seen very good ones made by Siemens as a servomotor and it is very much lighter than the ordinary aircraft actuator motors which are the smallest which have been available in England until a few months ago. Clearly with these magnetic materials coming out it may be well that the output of the electric motors will fastly improve within the next few years.

Mr. LORD: I think that it should be possible. No mention as yet has been made as to what the person is going to do. In the case of the paralysed patients from polio which is the type of cases that I personally deal with, and which are inevitably wheelchair cases, the maximum that they probably ever want to do is to lift load from point A to point B, because of the other complications, probably respiratory, etc., etc.

..... Yes, you mean to make one type of thing which is very practical, powerful and so forth, and the other kind very small and simple.

Mr. WILSON: Yes, but of corse there is a lot of work being done on hidden muscles that you work with, mostly helping hand.

Mr. LORD: This is probably departing from the subject, but I am not at all convinced of the worthwhileness in many places of the hidden muscles, although I use them. Because we have devised certain small pieces of quickly detachable equipment which will perform these functions.

Mr. WILSON: We have often felt that a small and short cylinder suitably placed would produce the performance of a given muscle and under some circumstances be less obtrusive. I think in relation to the activities which are required by a paralyzed person. Now we are managing to get away quite fine without any mechanism on the actual hand, so in fact we forget about it.

Mr. WILSON: The point that I was trying to make in my lecture is that one must consider in the greatest detail what the purpose of any particular device is, and then the

motor and its transition system which may be a splint or may be a prostheses must be designed and devised and thought out together. The McKidden muscle, I do not know whether you are all aware of the McKidden muscle, it is a very soft rubber type, nylon braid and when it is blownup, the rubber tubing expands sidewise and because of the nylon braid the tube shortens and gets flattered just as an ordinary muscle. This strikes one at first as an extremely ingenious and intellectually stimulating device, but it does not fit well with the control systems, it is non-linear and it is difficult to control and it does not fit in well with the transmission systems. So, one has got to think of the whole thing together and try to reduce all the complications to produce the simplest thing for the operation which is intended.

Mr. LORD:

Mr. WILSON: Yes, but you see there is a limit of pressure which you can use in the muscle whereas you can double the pressure in a piston-cylinder system and yet hardly make the thickness of wall any greater. It has got to be thick enough to stand all the normal blows that it might receive in the course of the ordinary living and provided that it is thick enough to do that and probably the cylinder wall is thick enough to stand up to the pressures that you can put inside.

Mr. LORD: What I was trying to say earlier was that we can commence with a limited goal by providing means for people with extensive paralysis to enable them to feed themselves. To do this in the wheelchair cases we have inevitably to use the hidden muscle with gas supply. We are now able to do the same functions without any power supply. But there is a need for this movement also.

Mr. WILSON: Yes, but we have used theses motors in feeders. Feeder is the American device which is a swinging arm on ball bearings and fastened to the back of the chair and the flaila arm is fastened to the end of the one so that the arm of the patient is supported. Two things are allowed at this point as well, so that the arm can be brought in all directions and the wrist can be raised by dropin the elbow. The mechanics of this, in relation to theshoulder joint, are such that as you bring the arm towards the body there is a tendency in any case of gravity to operate to bring the hand up, unless you take the hand away from the body the hand tends to go down, so that the little muscle power that some patients may have is sufficient to control feeding even though they have no shoulder control worth speaking of.

Mr. LORD(?) May I make a fact perfectly clear that this system is entirely dependent on there being present some form of trunk movement. It is not sufficient to do this against the gravity but sufficient to do that. Well, you can motorize that of course, and that is being done both with the system in America and we used our motors in the just same way to motorise the elbow part and by separating the 2 cylinders to produce a that proved very satisfactory and with that we were able to send the patients away to another hospital for a long period where they became two handed again and used their right hand to work with the left. The right hand was very paralyzed in one case but the patient used it as the paper weight to hold the side of the plate and so forth.

Mr. RESNICK: It is time to talk about the new type elbow motor developed by the American Institute of the Prosthetics Research. A pneumatic rotary motor has been developed by Mr. Keesling of the American Institute of Prosthetics Research and Development, N.Y. City, N.Y. It is oval in shape about 5 cm. x 4 cm x 3 cm in size. A piston which is oval in shape is forced from one end to another by compressed gas. A rotary member shaped in the form of a helix passes through the piston. As the piston moves longi-

tudinally, the helical member rotates.
There is a unit designer for the elbow of the prothesis that produces 50 inch-pounds of torque and another one for wrist rotation (supanation-pronation) which is smaller and of lower torque capacity.
When gas is locked in the motor it holds still and will support a load. The seals around the piston and helix do not leak.

CHAIRMAN: Before we proceed to the second part of this morning's session I would like to summarize the previous discussion in Serbocroat for our physicians and engineers. After that Mr. SWETTENHAM of London, will proceed with his paper. We begin now with the second part of this session. Mr.SWETTENHAM.

Mr. SWETTENHAM: Mr.Chairman, Ladies and Gentlemen,
When we showed this paper to one of people working in this field he complained that we were ignoring the work which has been already done by the other people. This is not our intention. We are well aware of the work which is being done, particularly at Heidelberg in Germany, and in New York, by the American Institute of Prosthetics Research and we believe that these two organizations have probably fitted more patients with arm prostheses than anybody else. When we wrote this paper we were particularly hoping that the representatives of these organizations might be available to give us their practical experience in the use of such equipment on amputees.

WHAT IS THE CLINICAL ROLE OF THE UPPER EXTREMITY POWERED PROSTHESIS? (paper distributed at the beginning of the Symposium).

CHAIRMAN: As you all know the probleme of upper extremity prostheses this is one of the really very interesting subjects. We know that extensive work is being done in the United Kingdom, USA, Germany on this subject and we hope that we shall have a good discussion on this one.