MYO-ELECTRIC CONTROL SYSTEMS : PRESENT AND FUTURE CLINICAL APPLICATIONS

R. N. Scott

Executive Director, Bio-Engineering Institute and Professor of Electrical Engineering

V. A. Dunfield

Research Associate, Bio-Engineering Institute and Ass't. Prof. Electrical Engineering

University of New Brunswick, Fredericton, N.B.

ABSTRACT

It is now five years since the first Canadian myo-electric control system was fitted for clinical evaluation, ten years since the first clinical fitting in the U.S.S.R., and 25 years since Dr. Reiter developed the first working myo-electric control system for an artificial limb. The medical profession, paramedical personnel and granting agencies are only right in asking whether or when such systems will be applicable to patients on a treatment rather than experimental basis. The answer to this question must also indicate those types of patients for whom the benefits justify the added expense of electronically-controlled externally-powered prostheses.

In this paper several recent fittings of myo-electric control systems to amputees will be described. From these, a summary of the present status of availability, applicability, and cost/benefit ratio will be developed. Also, a review of the limitations of present systems and of current research and development projects to overcome these limitations will be used as a basis for prediction of trends for the next few years. The paper will conclude with some observations on the changes in treatment facilities and procedures necessary to obtain maximum benefit from this work.

BACKGROUND

In a myo-electric control system, the electric signals from a muscle are used to control some externally-powered device, such as an artificial limb. International attention first was drawn to this topic by a U.S.S.R. presentation at the 1960 I.F.A.C. Congress in Moscow, [1]. A system had been developed and used much earlier in Munich [2], but unfortunately that system was not placed in production.

One of the major obstacles to rapid development and utilization of myo-electric control systems is the difficulty of coordinating clinical evaluation with technical development. The medical profession cannot specify design requirements without demonstration (or at least comprehensible explanation) of technical possibilities. The engineering profession cannot establish technical feasibility without extensive research, and must have some guidance as to potentially useful directions of research. Again, when a system has been designed it is very difficult to distinguish between poor performance due to inherent design errors and poor performance due to incomplete development, in evaluating its clinical usefulness.

Two contrasting strategies have been adopted. In England and the U.S.A. there is a tendency to carry out very extensive technical development prior to clinical evaluation or application. This ensures that systems with inherent technical defects will not reach patients - but also provides an opportunity for the development of systems which are technically excellent but clinically useless. In the U.S.S.R. and continental Europe, on the other hand, there is a willingness to fit large numbers of admittedly imperfect systems to patients in order to obtain evaluation data at a time when it can be used profitably in the development process. Predictably, Canadian strategy lies between these two extremes, in this instance with a bias towards early clinical evaluation.

PRESENT STATUS

Commercially available myo-electric control units, manufactured in the U.S.S.R., Italy, Austria and Germany are intended for the below-elbow amputee and require the use of two muscles to control closing and opening of an electric hand. In Canada, the three-state control system developed at U.N.B. [3] is being distributed to a number of Canadian and U.S. centres for clinical evaluation. This system permits full control of one function from one muscle, and is intended for use with any level of amputation and with a variety of electrically-powered devices such as hands, elbows and wrists. More complex systems are in various stages of development, particularly in the U.S.A., Japan and Sweden. In most cases these systems are still in the laboratory demonstration stage. Some of the more promising developments are described below.

One of the major problems in fitting myo-electric controls to amputees is that the high-level amputee has very few muscles available for use as control sites. Even one muscle per function, as required by the U.N.B. 3-state system and by modification of that system at Northwestern University and Case Institute of Technology, may be too restrictive. A system which utilizes pattern recognition techniques to permit control of many functions from a few sites, as developed at the Moss Rehabilitation Centre in Philadelphia, offers a possible alternative. Development of surgically-implanted myo-telemetry units is well advanced in England, Sweden, Canada and the U.S.A. These systems will permit access to deep muscles and utilization of small muscle remnants as control sites, and will provide one means of overcoming the problem of electrode motion artifact which plagues users of external systems.

The amputee is deprived of sensory and positional feedback, as well as physical function. Not only do present artificial limbs fail to replace the lost sensory function, they also fail to provide adequate functional feedback to permit their use without constant visual attention. As prostheses become more complex, this problem will become more acute, and it is encouraging that work has been initiated in Japan and the U.S.A. towards its solution.

The question of which patients should be fitted with myo-electric control (or with any externally-powered device) is difficult and depends upon rapidly changing circumstances. It is possible however to summarize the present situation. Clearly, the amputee with the most serious disability, e.g. the fore-quarter amputation, requires powered assistance more urgently than the below-elbow amputee. However, there are some cases where the functional and anatomic cosmesis provided by a myo-electrically controlled prosthesis are ample reasons for its use by a below-elbow amputee. The quadriplegic patient has an urgent need for functional assistance, and myo-electric control is often feasible. The problem here is that available powered orthoses are neither functionally adequate nor cosmetically acceptable, except to a very small fraction of the patients.

THE FUTURE

The major development in the near future will be the adoption of implanted myo-electric telemetry systems at the time of primary surgery. Frequently this will be coupled with immediate post-surgical fitting of functional prostheses, as has been demonstrated at Northwestern University. More functions will be provided for the severely handicapped amputee, and improved muscle stimulation techniques will go a long way toward the solution of the problem of the high level quadriplegic patient.

ACKNOWLEDGEMENTS

This work is supported primarily by grants from the Department of National Health and Welfare (Public Health Grant 603-7-13) and the National Research Council (Operating Grant A-1083), with assistance from the Medical Research Council, Canadian Rehabilitation Council for the Disabled (N.B. Division) and Workmen's Compensation Board (N.B.).

REFERENCES

1. Kobrinski, A. E., et al, "Problems of Bio-electric Control," Trans. 1st Int'l Congress on Automatic Controls, Vol. 2, pp. 619-623; London, 1961.

2. Reiter, Von Reinhold, "Eine Neue Elektrokunsthand," Grenzgebiet der Medizin, Vol. 1, No. 4, pp. 133-135; 1948.

3. Dorcas, D. S., Dunfield, V. A. and Scott R. N., "Improved Myo-Electric Control Systems," accepted for publication in Medical and Biological Engineering, 1970.