

Rehabilitation engineering—a developing speciality

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Introduction

Recent estimates made by the Social Security Administration (SSA) and the Swedish Institute for the Handicapped (National Research Council, 1976) indicate that between 10 and 12 per cent of the population are handicapped. Using the lower figure and estimating on the conservative side means that there are approximately 20 million handicapped individuals in the United States. The SSA figure also indicates that about 8 million are able to work either normally or in a limited capacity and 7½ million are unable to work at all. By deduction, the remaining 4½ million must be comprised of those from the young and geriatric populations. The loss of productivity plus the financial burden borne by federal and state programmes are estimated to be in the billions of dollars. Of course, these financial burdens are in addition to personal losses suffered by physically handicapped individuals resulting from their inability to participate in many aspects of life—losses that cannot be measured in dollars.

A conservative estimate is that technology can be potentially beneficial to at least 50 per cent of the physically handicapped population (10 million people in the United States). Prosthetics and orthotics have been the primary source of technology for physically handicapped over the years. Recent studies conducted by the Committee on Prosthetics Research and Development—National Academy of Sciences (le Blanc, 1973) indicate that approximately 4 million individuals benefit directly from prosthetic and orthotic services. This means that a remaining 6 million individuals stand to benefit from additional types of technology that are presently unavailable to them.

Recent experience with this latter population indicates that judicious application of tech-

nology can have beneficial effect by increasing the independence of individuals, thereby reducing cost of care and increasing their involvement in productive job activities. At present only a very small fraction of the capabilities of modern technology are being effectively utilised to aid this population.

Traditionally, engineers in the field of rehabilitation have been involved largely on the periphery undertaking research and development projects in areas such as prosthetics and orthotics, but rarely becoming involved directly with patients. That is, very few engineers have become truly integrated into the clinical setting as functioning members of clinic teams. As a result, engineering has remained merely as a desirable supplement to clinical treatment rather than becoming an integral component in the rehabilitation process.

Throughout the 1960s attempts were made to transfer sophisticated technology developed by NASA and the computer industry and other space-age technical spinoffs into the clinical setting. This effort was abandoned after eight years as no significant success had been achieved. The major difficulty stemmed from an inability of the involved disciplines to communicate effectively; and from the fact that there was not a mechanism within the clinical environment that could integrate the technology in a manner that was acceptable to patients. A more realistic approach has placed engineers, physicians, and related professionals together in a clinical setting to work directly on patient problems. This approach has been termed Rehabilitation Engineering, and distinct from their biomedical or bioengineering research-oriented "half-brothers", the new breed of engineers in this subspecialty are becoming known as rehabilitation engineers.

The Role of the Rehabilitation Engineer

The broad objective of rehabilitation engineering is to enhance the lives of the physically

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handicapped through the clinical application of a total approach to rehabilitation; combining medicine, engineering and related science and technology. The prime function of the rehabilitation engineer is to bring an organized approach to patient problem solving, through problem definition, analysis, synthesis, and application of solution.

It is evident that the scope of rehabilitation engineering must be broader than the traditional focus of prosthetics-orthotics in order to be responsive to the needs of all aspects of a handicapped individual's life, i.e. education, vocation, daily living, recreation and creativity. It is conceivable that rehabilitation engineering activities can be carried out anywhere that consumers require the service. Some examples are; rehabilitation hospitals and centres, special public schools, industry, special living environments, research laboratories, insurance companies, vocational rehabilitation departments, consulting services, government health departments, teaching programmes, standards committees, and private charitable organizations. It therefore follows that within the scope of rehabilitation engineering there will be individuals with different interests and job activities. There will be those who prefer to work solely in areas of teaching, research, and development with only limited contact with clinical activity. However, within the rehabilitation process, the unique aspect of the rehabilitation engineer is that he functions as a member of the clinical team, and has the training and experience necessary for the successful delivery of technology to those who require it. Additional functions of the rehabilitation engineer are to: a) be knowledgeable of all potential resources that can be utilised on the behalf of the handicapped, b) assist in identifying and defining the clinical problem, c) develop a procedure for providing a possible solution, d) work with rehabilitation professionals, other engineers, and technicians to provide solutions, e) assume responsibility for eventually finding a solution that is acceptable to the consumer.

It is anticipated that patient needs outside the scope of currently practised prosthetics-orthotics is the main activity area in which the rehabilitation engineer will grow his deepest roots and ultimately make the greatest contribution in terms of direct benefits to patients. Within this sphere of activity the rehabilitation

engineer is assuming responsibility for patient case loads, and working directly with doctors and therapists in the management of patients with a wide diversity of rehabilitation problems. The most obvious activity areas are; special seating, pressure sore prevention, mobility, bio-feedback training, non-verbal communication devices, transportation, environmental control, and work environment modifications.

Relative to prosthetics and orthotics, it is visualized that the rehabilitation engineer will function in the capacity of technical consultant, particularly related to patient problems that require the application of more sophisticated technology. For example, the engineer may be of valuable assistance to the orthotist or prosthetist on the problems that require the application of materials such as newer plastics and light weight/high strength alloys, advanced electronics, or unique mechanical designs.

In the realm of research, it is the author's opinion that the rehabilitation engineer as described above should not be considered a basic researcher, since his primary interest and charge is the direct application of current technology to patient problems. However, his clinical exposure gives him the unique opportunity to identify and define many complex clinical problems, which can then be transmitted to research scientists for solution. In this capacity the rehabilitation engineer acts as a resource person who is primarily involved in the early definition stage of a research project, and then again in taking the results of research and converting them into practical clinical applications. Therefore, relative to basic research it is important that the rehabilitation engineer maintains an open communication between other professionals within the clinical setting, the patient, and his research colleagues in order to affect the best solution to complex clinical problems.

Relationship with Peer Professionals and Consumers

The practising rehabilitation engineer at one time or another must associate with approximately 15 different peer professionals—and so do without offending those who basically resent the intrusion of Captain Marvel with his black boxes and flashing lights. Within the sphere of the traditional rehabilitation process, the

engineer would function as a member of the clinical team and assume equal status to other professionals on the team—with the physician retaining the ultimate responsibility for patient welfare. As the scope of rehabilitation engineering develops to encompass more areas of activities outside the established rehabilitation process, the engineer may function in a consultant capacity, on a fee-for-service basis, and assume legal and ethical responsibility for the services provided.

Since the field of prosthetics-orthotics has long served as the major contributor of technology for the rehabilitation process, some view the evolution of rehabilitation engineering as an encroachment upon the achievements made or the future developments of the prosthetic and orthotic professions. It must be recognized that all fields have both unique and common areas of contribution to make to the lives of the handicapped. Rehabilitation engineering in no way should supplant or infringe upon the growth of prosthetics and orthotics. Rehabilitation engineers, unless having had certification in prosthetics-orthotics, are not competent to provide prosthetic-orthotic devices to patients. However as mentioned, they can have a technical area of expertise that when combined with a basic understanding of the field of prosthetics-orthotics can serve as a valuable technical resource. If one takes the view that in clinical activities that are basically within the realm of prosthetic and orthotic experience the rehabilitation engineer should assume the role of consultant, and in other technical areas the rehabilitation engineer should assume the primary responsibility for technical delivery and call upon the expertise of the prosthetists-orthotists as consultants—then crossing of boundaries can be done in a spirit of co-operation and goodwill. Of course there will always be "grey areas" and the technical responsibility for an individual patient may bounce back and forth between the disciplines; depending on the type of problem, the course of a patient's improvement, and the point in the time—continuum of the individual's rehabilitation process.

The rehabilitation engineer should at all times remain sensitive to the needs of patients. He must attempt to gain insight into human behaviour, particularly relative to the pressures experienced by the handicapped in their daily

lives, and inject these realities into the technical goal-setting process. He must at all times be cognizant of the intricate balance between cost and real benefits derived, and in some cases be prepared to withhold technology when the cost-effectiveness ratio becomes highly questionable.

The relationships of the rehabilitation engineer must also extend beyond the sphere of the rehabilitation centre. Upon the successful research and development of any new device the rehabilitation engineer has the responsibility to make the development available to all patients who can potentially benefit. This may mean consultant activities with local and international manufacturers and suppliers, involvement in co-operative programmes involving other developmental centres or private facilities; as well as providing support to national and international organizations that may wish to carry out evaluations or educational programmes on a larger scale.

Work Environment

In order to carry out his prescribed role in the clinic team, the rehabilitation engineer ideally should be located in, or adjacent to, a clinically based medical-technical programme which encompasses in-patient and out-patient medical services, therapy, prosthetics-orthotics, engineering services, applied research, teaching, with access to basic research resources as required. As a functioning member of the clinical team with an active caseload, the engineer must have resources at his disposal for designing, fabricating, supplying and maintaining a wide variety of technical devices for patients. In order to carry out his activities effectively, adequate resources must be available in terms of mechanical and/or electronic fabrication facilities located in reasonable proximity to the clinical setting. Naturally, the extent of the support resources are dependent upon the types and numbers of patients being served. Generally, a rehabilitation engineer should have 3 to 4 support technicians plus secretarial assistance, so that most of the devices can be fabricated or modified on site without excessive time delays.

It is felt by some that in addition to the researcher, prosthetist-orthotist, and rehabilitation engineer there is need for another level of individual—a rehabilitation engineering technologist. It has been proposed that this person

would essentially be "the hands" of the engineer working directly with patients under his direction. However, this view has not been supported in general on the basis that it is neither necessary nor desirable to have a technician acting as the interface between the engineer and the patients since direct patient contact should remain the primary responsibility of the engineer. Also, the support skills usually required are already available in the form of machinists, electronic technicians, draftsmen, etc.

Education and Certification

Establishment of educational programmes that will meet immediate and future manpower needs remains as a priority goal in the systematic evolution of the field. A recent workshop (University of Tennessee, 1976) has generated guidelines for the development of rehabilitation engineering education and certification. The major recommendations of this workshop can be summarised as follows.

First and foremost, it is recommended that the rehabilitation engineer be a competent engineer in a traditional engineering specialty, supplemented by advanced training in the subspecialty of rehabilitation engineering. The advanced training should generally result in a second degree (Master's) which comprises both didactic and clinical experience. The clinical experience (or internship) should involve approximately one-half of the advanced training time in which exposure is gained into activities of other rehabilitation disciplines, plus direct experience with problems of patients involving both children and adults.

In parallel with the development of a formal education programme is the need to develop short-term continuing education courses. These courses would be on a variety of topics depending on the current needs of both engineers and other professionals involved in rehabilitation engineering activities.

Regarding certification, it is recommended that a certification process be instituted in rehabilitation engineering to assure adequate consumer protection and recognition of the qualified rehabilitation engineer. It was felt that individuals should first be licensed as engineers and then obtain certification as rehabilitation engineers after completion of recognized course

work plus the appropriate length of practical experience. The existing Biomedical engineering societies should be approached to convene an appropriately constituted committee to consider the details of certification of rehabilitation engineers. In general, it was felt that certification should establish minimum standards or requirements for rehabilitation engineers and that it should imply recognition rather than licensing. It is further suggested that initial examination be required, plus periodic continuing education experience in order to maintain certification.

Summary

Rehabilitation engineering is a new and rapidly developing specialty of medical engineering; with the unique goal of directing advances in technology towards enhancing the lives of physically handicapped individuals. The rehabilitation engineer is an engineer who has acquired specialised training and experience so that he/she may function as an effective member of the clinic team and assume responsibilities for the delivery of engineering technology to patients.

The sphere of activity of the rehabilitation engineer must transverse many of the disciplines and boundaries involved in the traditional rehabilitation process in order to be effective in community based problems such as; transportation, home and work environment modifications, and activities of daily living including recreation and creativity.

The field is only in its infancy stage and many problems remain unsolved. Paramount to the successful evolution of the field is the need for a recognised educational process including certification that will recognise those who have acquired the necessary training and experience. Finally, a delivery system must be developed that will contain the necessary employment opportunities and resources through which the rehabilitation engineer can fulfil his commitment as a technical member of the clinic team.

In recent years, advances have been made in many countries, the most significant being in the United States where strong federal support has been legislated. In most other countries, advancement has been commensurate with the degree to which the public and their elected government representatives have recognised the potential of the field and have appropriated the

required funding. It therefore follows that until rehabilitation engineering is generally accepted as a responsibility of society, identification of adequate financial support will remain as the primary impediment to its growth and development. To this end it is imperative that early clinical successes be achieved within the established programmes in order to demonstrate the value and potential worth to the handicapped population of this new and developing specialty.

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