CLINICAL PROBLEMS WITH PROGRAMMES OF FUNCTIONAL ELECTRICAL STIMULATION FOR PARAPLEGIC PATIENTS

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ABSTRACT

Programmes of electrical stimulation to restore lower limb function in spinal cord injury patients have been developed at the Royal National Orthopaedic Hospital, over the past five years. The aim of this paper is to identify and discuss clinical problems encountered by patients following a programme of functional electrical stimulation to the muscles of the lower limb and to discuss their management and subsequent outcome to facilitating preventive measures for future programmes.

KEY WORDS: Functional electrical stimulation, Paraplegics, Assessment, Patient management

INTRODUCTION

The goal of rehabilitation is to restore the individual to his previous state or to enable that individual to achieve the highest level of function accessible to him. Functional Electrical Stimulation (FES), the artificial activation of paretic muscle by electrical stimulation of motor nerves, has been used in the rehabilitation of spinal cord injury patients for thirty years to provide physiological, physical and psychological gains [1,2,3].

Many studies have investigated the use of FES as a means of restoring function such as standing [4,5] and gait in paraplegics [6]. Further studies have identified the therapeutic benefits that may be brought about by programmes of electrical stimulation. These include increased circulation and muscle bulk [7], increase in muscle force [8] and a reduction in spasticity [9].

Explicit criteria for patient selection have been devised through experience during such studies, to exclude unsuitable patients [1,5,9]. In spite of such criteria, problems may still be experienced with patients at the outset and throughout the course of the programmes. A review of the literature indicates that most problems encountered during FES programmes result in patients withdrawing from the programmes [for example 5,6].

The F.E.S. Research Unit has been established at the Royal National Ortopaedic Hospital, over the past five years, during which time programmes of electrical stimulation to restore lower limb function in spinal cord injury (SCI) patients have been developed. Stimulation of the quadriceps and gluteal muscles is used to produce standing [5,8] and the addition of common peroneal nerve stimulation produces a flexor withdrawal response to elicit the swing phase in gait [11].

At the onset of the research programmes, enrolment of patients was highly selective. As the trials continued, the number of patients withdrawing from the programme increased; however, due to the restricted pool of patients to select from, it became necessary for some patients to be reconsidered for further projects in spite of their some perceived problems.

The purpose of this paper is to identify problems incurred by patients following a programme of functional electrical stimulation to the muscles of the lower limb and to discuss their management and later measure for future programmes.

CLINICAL PROBLEMS

Patient compliance

Patients were self-volunteered for the projects and therefore had a high level of motivation but patients compliance was still compromised by other factors.

Patients were given thorough instruction in the use and care of the home exercise stimulator and the electrodes, with great emphasis placed on the safety precautions. A daily chart was supplied indicating the exercise programme and positioning of the electrodes. All patients were required to set themselves up for stimulation in laboratory, to the satisfaction of the therapist before commencing the home programme.

Weekly reassessment showed errors in the patients' method of stimulation. Incorrect stimulation has been followed particularly placement of electrodes led to a lack of strengthening in the anterior tibial muscles an increase in plantar spasticity with resultant shortening of the gastrocnemius muscle. One subject failed to perform the safety check on his electrode leads and experienced a small but deep skin burn from a frayed wire.

Great emphasis must be placed on patient education, reinforcing the instruction with simple literature and illustrations. The stimulator must be simple to operate, to maintain a high level of compliance. Weekly reassessment of the patients ability to apply the stimulation is also essential to ensure satisfactory results.

Lower motor neurone dysfunction

Neurophysiological studies were carried out during a programme of FES, to achieve standing in nineteen subjects with complete thoracic SCI [5]. Lower motor neurone dysfunction was present in five subjects; there was diffuse EMG abnormality in four patients and evidence of isolated peripheral nerve damage in one. Muscle strengthening was not achieved in those with diffuse EMG abnormality. The presencr

of a significant abnormality in the common peroneal nerve of one patient did not compromise strengthening to stand, but prevented that patient form participating in a subsequent trial which required the presence of an adequate flexor withdrawal response.

Spasticity

Patients were assessed before commencement of a programme of stimulation to eliminate remediable causes of spasticity such as urinary tract infection, viral infection, lack of passive stretching and standing, skin trauma eg. due to a poorly fitting orthosis and following bladder implant surgery. During stimulation an increase in spasticity was seen in some patients with a previously constant level of spasticity [8], bur no factor to predict such an outcome could be identified.

The use of medication (Baclofen) in two subjects with an increased level of spasticity following stimulation, caused minimal reduction of spasticity and a decrease in the muscle force of the quadriceps muscle such that the patient were unable to stand and withdrew from the programme

It is important to assess the level of spasticity before commencing the stimulation but also to continue monitoring throughout the course of the programme. Fluctuation in the level of spasticity is to be expected but a continuous increase must not be left untreated.

Articular changes

One patient developed crepitus in both knee joints and internal rotation of the femur on the tibial. This was accompanied by an increase in muscle spasticity and a decrease in muscle force. Stimulation was stopped and X-ray investigation showed osteophytes present in the cruciate ligaments in both knees and some arthritic changes in the articular surfaces. Previous X-rays had not been taken before the programme and therefore no comparison could be made.

Subsequently, X ray investigation of hip and knee joints was included in pre-programme assessments for all patient, but flexion deformities developed in both hips of the second patient, such that surgical excision of the bone was necessary to prevent loss of function.

Many of the patients involved in lower limb programmes experienced a decrease of joint range of movement, particularly in the ankle and foot. This may have been due to lack of correct passive stretching or an increase in extensor spasticity following stimulation. In standing, the loss of plantargrade position of the foot caused flexion at the hips and a subsequent increase in lumbar lordosis, resulting in poor standing posture.

These patients were retaught correct passive stretching, encouraged to rest in prone lying and instructed to stand daily for a minimum of thirty minutes. All patients regained ankle range of movement to plantargrade and hip extension.

It is therefore of great importance to continue monitoring joint function including range of movement regularly and maintain standing and prone lying stretching calf muscles and hip flexors.

Postural deformities

When quadriceps were stimulated in isolation, patients stood with some flexion at the hips and an increased lumbar lordosis. This posture was corrected to the midline with the application of gluteal stimulation and voluntary contraction of latissimus dorsi m. to stabilise the upper trunk.

Spinal deformities were seen in three patients, with complete lesions at the level of T_{10}, T_6 and T_7; postural scoliosis in the first two and a marked lumbar lordosis in the third. The first patient developed a thoraco-lumbar scoliosis as a result of muscle imbalance following implant surgery fro a bladder stimulation, the second as a result of poor sitting posture and an increase in spasticity of the abdominal musculature. The deformity caused an alteration in balance in standing due to disalignment of the pelvis. This consequently caused problems in the swing phase of gait. The tow patients with scoliosis were able to correct the scoliosis with the use of a mirror in the laboratory and were encouraged to self-correct at regular intervals throughout the day and to perform an extensive home stretching programme.

The third patient presented with a markedly increased lumbar lordosis in the standing position which was uncorrectable with gluteal and paraspinal stimulation. The lumbar spine was fused with Harrington rods and the patient resumed his standing programme after six months with corrected posture.

Patients should be screened for spinal deformity. i.e. lordosis and scoliosis before commencing a programme and monitored at regular intervals throughout the programme, particularly in further procedures, such as bladder implant surgery.

Soft tissue injuries

Injury to muscle, ligaments and the joint capsule may occur as a result of or irrespective of the stimulation. If left untreated, the injury will become chronic and give rise to further changes such as an increase in spasticity or a decrease in muscle strength.

One patient developed effusion of both knee joints and suprapatellar bursae, accompanied by an increase in muscle spasticity. Stimulation was stopped and no decrease in spasticity or joint effusion was noted. The cause of the chronic bursitis was diagnosed to be the suprapatellar strap of the patient's long leg calliper which was causing a chronic irritation of the bursae. The straps were replaced with leather pads covering the knee with a resultant decrease in the soft tissue swelling and a reduction in spasticity.

Soft tissue injuries may occur during exercise or as a result of other activities. The cause should be influenced and managed accordingly.

Skin

One patient developed a small blister at the edge of an electrode when he did not remove the electrode after stimulation; the probable cause of the lesion was friction. No other electrode burns were experienced by any of the patients, although in increase in erythema post stimulation was seen, particularly with the monophasic stimulation; this always faded within one hour.

The self-adhesive electrodes were changed at regular intervals, particularly those used for gluteal stimulation which deteriorated more rapidly than those used in quadriceps.

Great emphasis must be placed on skin care for the patients and their carers and this should be reinforced on each attendance and when changing stimulators.

Stimulators

In a unit where facilities do not permit the development of muscle stimulators, clinicians rely entirely on such stimulators being made readily available on the commercial market.

Experience has shown [5] that the choice of an appropriate exercise stimulator is essential particularly about sufficient power output. Several patients did not gain sufficient restrengthening with one make of stimulator, but than improved dramatically when given a different make of stimulator.

The stimulator must have sufficient channels and adequate programmes, to facilitate use by the patient. An insufficient number of channels will increase the time needed for stimulation and therefore the patient is more likely not to fulfil his exercise regimes. Four channel should be regarded as the minimum acceptable for lower limb exercise.

DISCUSSION

The range of problems encountered in patients in FES programmes is discussed. Those working with patients should have a full awareness of the potential for such problems to develop. Systematic study of patients must be continued throughout the course of stimulation as well as at the time to entry the programme. It is only in this way that problems, which can have major implications for the patients which can lead to inefficient resource utilisation, may be avoided or treated at the earliest opportunity.

These issues can become particularly important when patients progress to an implanted system. For example, one patient who had been utilizing a lower limb ambulatory system at home, developed infection after a procedure to remove heterotrophic ossification. As a result of this and further complications, he spent most of the following year in hospital; he lost his business, and health care costs in excess of 75000 $ were incurred. He remains unable to use his system. Systematic monitoring of such patients may help prevent the occurrence of such a sequence.

The management of patients undergoing programmes of FES must become multidisciplinary. It is essential for the patients to be assessed and monitored by

physicians ,therapists and engineers throughout the course of the programme. Coordination and communication among all personnel involved with patient are vital and may be promoted by the use of case conferences. Through this holistic approach, any change in the patient state may be identified immediately and the appropriate measures taken.

CONCLUSION

This paper identifies the problems incurred by patients following programmes of FES to the muscles of the lower limb at the Royal National Orthopaedic Hospital, Stanmore, England and describes the measures taken to address those issues. The authors stress the importance of sensitive and objective measurements in the initial patient selection but also regular assessment and monitoring of the patient, to early detection of such problems, throughout the programme.

These findings have enabled introduction of preventive measured into our subsequent research programmes. We believe that his will enable greater numbers of paraplegic patients to benefit from our lower limb programmes of functional electrical stimulation.

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