General Considerations In The Clinical Application Of Electrical Stimulation

The purpose of this presentation is to introduce practical applications of electrical stimulation [ES] in the management of disabilities encountered in everyday clinical settings. It is written in a fashion to help patients, families, clinicians (who are unfamiliar with electrical stimulation), insurance carriers and other third party payers to understand how ES can be incorporated effectively into treatment protocols. The term “functional electrical stimulation” implies that the user will have an improvement in their daily function as a result of ES.

There are several basic and extremely important considerations in determining if electrical stimulation is indicated.

- Each patient is like an individual fingerprint in terms of his or her needs. A knowledgeable clinician or clinical team is required to determine candidacy for ES.

- There must be a very specific goal or expected outcome that will improve daily life in a way that can be objectively measured before ES is prescribed for a patient.

- While the benefits of ES for a particular application may be realized within a few days, often it is necessary to use ES for an extended period or even for the rest of the patient's life. For example, when ES is added to an exercise protocol to augment the return of muscle control, once the desired control has been achieved ES is no longer required. If, however, volitional control does not return to a useful level, continued ES may be necessary to support function. There are many instances when the withdrawal of ES would be detrimental to function and so it is continued on a daily basis. The expected time for use of ES as well as the responsibility to be borne by the patient and family must be understood by all parties.

- Effective ES is not a treatment that is provided only for a few minutes during clinical visits. If it is to be effective, ES must be available to the patient around the clock at home, school or work. For example, if the goal of ES is to gain wrist mobility after wrist fracture and removal of the cast, ES can be used at home several times a day with excellent results when compared to three clinical visits per week for four or more weeks. If ES is employed to help the patient relearn to exercise muscles after injury, ES can be used at home during every exercise session. When recovery of muscle function is insufficient, ES will be needed every day to substitute for the lack of voluntary muscle control. This may be true for the stroke patient with a subluxing shoulder or the brain injured patient who requires ES to keep the toes from dragging when taking a step.

- The majority of ES users will have sensation or the ability to feel the effects of the electrical current flow. ES must be comfortable if treatment is to be successful. Stimulation characteristics such as current type, waveform, pulse duration, pulse repetition rate, intensity and modulation are critical issues in ES with skin as well as implanted electrodes.

- When involuntary muscle contraction results from stretching the muscle [called spasticity] and interferes with positioning or movement in disorders of the brain and spinal cord, ES may reduce the unwanted muscle contractions and unmask

existing voluntary muscle control. THIS IS AN EXTREMELY IMPORTANT CONCEPT. ES may reduce interfering spasticity WITHOUT causing weakness or paralysis of the muscles required for function. A trial of ES is warranted prior to instituting chemical, drug or surgical measures that may reduce spasticity but paralyze the muscles. When ES alone does not adequately reduce interfering spasticity, a combined strategy may be effective with lower doses of medication or less aggressive surgical intervention.

- ES is most often integrated into a rehabilitation plan, as one component of treatment. While it may speed up the rehabilitation process, reduce the number of clinical visits, reduce cost and increase the expected outcomes, it is seldom a "stand-alone" intervention.

- Although the cost of ES will vary from one application to another, cutaneous or skin electrode systems are relatively inexpensive. Rental or lease options bring the cost down to the equivalent of 1 or 2 clinical visits per month.

- Knowledgeable clinicians [physicians and physical therapists] in any treatment setting can guide the patient in obtaining and using appropriate ES devices.

- Sophisticated, surgically implanted ES technology, such as that designed to give the high quadriplegic patient hand function or to give the spinal cord injury patient control of the bladder and bowel, can be expected to cost substantially more. These systems are provided at specialized centers in a few countries around the world.

Practical, functional applications of electrical stimulation are described for each of the following disabilities. The information will give the patient, family, clinician and third party payer general information designed to facilitate discussion between patients and medical caregivers and to enhance understanding by insurance carriers and other agencies that are responsible for allocation of health care resources. It must be recognized that these are general guidelines and that each patient will need to consult with their medical caregivers about their specific treatment options. Selected references are provided for further reading.

1) Orthopaedic disability after traumatic or infectious injury and surgical intervention.
   a) Prevent deep venous thrombosis
   b) Modulate pain
   c) Maintain or gain joint range of motion
   d) Augment muscle strength and performance
   e) Encourage bone deposition in delayed bone healing

2) Muscle weakness or paralysis with compromise of the peripheral nerve. Considerations for optimal rehabilitation outcomes.
   a) Peripheral Nerve Injury
      (a) Maintain joint range of motion.
      (b) Minimize fibrosis within muscles [in completely denervated
         (i) muscles awaiting reinnervation].
      (c) Minimize pain associated with peripheral nerve injury.
      (d) Research interest in function electrical stimulation of permanently denervated muscle.
   b) Loss of peripheral nerve [motor nerve cells in the spinal cord]
         (i) after spinal cord injury.

c) Loss of motor nerve in association with inherited or acquired disease.

3) Idiopathic scoliosis or spine deformity.
   a) Maintain or reduce the spinal curvature when the lateral curve is less than 35 degrees and skeletal growth is expected to continue for 2 or more years.

4) Stroke and Traumatic Brain Injury.
   i) In the first weeks or months after onset:
   b) Prevention of deep venous thrombosis
   c) Encouragement of the return of voluntary movement
   d) Reduction of a subluxing, and possibly painful, shoulder
   e) Prevention or correction of joint contractures
      (1) - Management of spasticity [one type of involuntary muscle activity] and associated pain
   f) Stabilization of the hip, knee and ankle for standing and moving from
      (a) one seat to another
   g) Assistance in advancing the lower limb to take a step
      i) After initial recovery has plateaued:
   h) Continue maintenance [or correction] of joint contractures
   i) Continued management of spasticity and associated pain
   j) Assessment of muscle activity that is interfering with function [Is the brain sending the wrong signal?]
   k) Continued use of ES to encourage muscles to work effectively
   l) Neural prosthetic applications: ES everyday for routine daily activities

5) Spinal cord injury.
   i) In the first few weeks and months after SCI:
   b) Prevention of deep venous thrombosis
   c) Prevention and management of pressure sores
   d) Ventilatory assistance [breathing and coughing]
   e) Encouragement of the return of voluntary movement
   f) Reduction of a subluxing and possibly painful shoulder
   g) Prevention or correction of joint contractures
   h) Maintenance of bone mineral density
   i) Management of spasticity
   j) Stabilization of the hip, knee and ankle for standing and moving from one seat to another
   k) Assistance in moving the lower limb forward to take a step
      i) After initial recovery has plateaued:
   l) Continued use of ES to maintain or gain joint range of motion
   m) Continued management of spasticity
   n) Continued ES to encourage muscles to work effectively for daily activities
   o) Neural prosthetic applications [for use of the hand and arm, to allow standing and reaching for objects, limited stepping and for the incomplete SCI limited walking may be possible
   p) Bladder and bowel management
   q) ES exercise of large, lower limb muscles to maintain heart muscle mass and heart function

6) Cerebral Palsy.
   a) Maintain or gain joint range of motion
   b) Manage spasticity [may be reflected in better range of motion and less pain as well as

improved muscle strength, breathing and swallowing and eating].
   c) Unmask voluntary control that was previously not useful because of spasticity [muscles will appear stronger]
   d) Encourage muscle activity at an appropriate time for hand or leg use [muscles may appear to work better or be stronger]
   e) Neural prosthetic applications of ES to substitute for "paralyzed" or weak muscles for improved hand function, sitting and walking.

7) Multiple Sclerosis.
   a) Maintain or gain joint range of motion
   b) Manage spasticity and unmask existing voluntary control as well as reduce pain associated with spasticity
   c) Improve walking ability
   d) Reduce urge incontinence

8) Amyotrophic Lateral Sclerosis.
   a) Manage spasticity and associated pain
   b) Unmask existing voluntary muscle control resulting in better "strength" and control
   c) Maintain or improve joint range of motion

9) Cardiac Assistance.
   a) Provide assistance to the failing heart by moving a shoulder muscle to the heart and using ES to contract the transferred muscle.

10) Incontinence [Urinary and Fecal Incontinence].
   a) ES of nerves supplying the muscles of the bladder and the pelvic floor to control urination or defecation. [Please note: the ES systems for control of bladder and bowel in spinal cord injury are discussed in the spinal injury section.]

11) Pain Modulation.
   a) ES of the spinal cord to manage pain.

12) Muscular Dystrophy.

13) Upper Airway Disorders.

14) Deep Brain Stimulation for Motion Disorders.

15) Sensory Neural Prostheses for Hearing [Cochlear Prosthesis].

16) Sensory Neural Prostheses for Vision [Retinal Prosthesis].