Developmental research in paraplegic walking

An injured London policeman's fight to stand and walk again, despite the handicap of complete paraplegia at thoracic level from a gunshot wound, captured the public imagination last year. British journalists hailed as an important breakthrough his treatment—firstly, with an electrical stimulation system (functional electrical stimulation) for the paralysed lower limb musculature, then using a splint to support his trunk and legs while continuing functional electrical stimulation to important propelling muscle groups.

This media interest was, unfortunately, concentrated on work in the United States—to the dismay of many other groups working on the same problem in Britain and Europe. Treatment centres for patients with spinal cord injuries and the self help agencies (for example, the Spinal Injuries Association) have been aware of these research efforts but have rightly and responsibly treated all claims with some scepticism based on their knowledge that rehabilitation to a life in a wheelchair is still a vitally necessary part of successful recovery from paraplegia or tetraplegia. Indeed, the problems of the acute injury quickly become superseded by intense efforts to educate these patients in how to care for themselves safely after hospital discharge.

Splints are used as part of rehabilitation but are often heavy and difficult to put on and off, and standing often requires help. Athletic adult paraplegics with incomplete or cauda equina lesions may walk with the so called "swing through" or paraplegic gait using crutches. Those with complete paraplegia at thoracic level find this tiring since the whole weight of the body has to be lifted upwards and then swung forwards using the arms. Gordon and Vandervalde showed that this motion consumed six to eight times more energy than normal walking.[1]

Developments in splinting techniques have eased this burden. The use of lightweight materials is not a complete answer, but an analysis of the principles of handicapped and normal walking by Rose *et al* has led to an orthosis (or splint) that provides low energy cost reciprocal ambulation (that is, one leg follows another in swing).[2,3] This provides independent walking for patients with thoracic paraplegia of any cause—and it is available in Britain. Similarly a less rigid splint, or brace, has undergone development by Douglas (an orthotist) in the United States. Dias and colleagues have shown this to work,[4] but some extravagant claims have been made by others and have led to uncertainty about prescription criteria. Functional electrical stimulation systems alone are said to be as effective as orthoses[5] and are under scientific evaluation.[6-9] A theoretical objection—borne out by increasing experience in various centres—has been fatigue induced in the stimulated paralysed muscles. If the lower motor neurone is intact it is forced to respond to electrical discharge. Sequential stimulation is needed, using multichannel control of propulsive and antigravity muscles, but the problem of synchronisation to the swing and stance phases of gait, though not insuperable, requires elaborate control both in the "hardware" and also by the patient. Furthermore, the patient may become exhausted, and this is not entirely overcome by training regimens of two to three months' graduated stimulation performed by each patient to "beef up" the paralysed muscles. The need for continuous contraction of the antigravity musculature to maintain the standing posture worsens the patient's fatigue. The possibility of damage by unnatural stimulation is a more fundamental objection raised by G Kidd (personal communication) and others, and continuing research is required to find ways of achieving optimal stimulation. The amplitude and duration of the current pulse, its repetition, and reliability in electrode placement and function all have effects. At a recent conference sponsored by the European Economic Community the consensus was that implantable devices should be used to get better sequential muscle contraction and function.

The shortcomings of functional electrical stimulation walking alone have thus become increasingly obvious with use, and serious problems remain. The patient still has to make considerable efforts to stabilise his hip and trunk (there is no functional electrical stimulation constraint of hip movement), and—very important—there is no transfer of energy from one step to the next: each is an isolated phenomenon, so progression is slow.

Clearly, then, a hybrid device combining the advantages of orthotic support with the addition of functional electrical stimulation to drive the legs forward seems a sensible research compromise. It should reduce the patient's energy consumption and allow the muscles to recuperate when stimulated only intermittently. The orthosis may be designed to give some degree of feedback and control to the patient as he maintains intrinsic stability.

A British system of this kind was described in September 1985 at the Edinburgh meeting of the International Medical Society of Paraplegia by McClelland *et al.* This system reduces the overall crutch impulse force by between 20% and 36%—proof that the key to successful high level paraplegic walking lies in attempts to lower its energy cost. Other measurements of the physiological cost of experimental walking techniques seem to confirm this achievement.

Research groups working on these problems should prove and publish the facts about energy costs before allowing any hybrid device to be anything more than an exciting glimpse of the future. But the patient with high level complete paraplegia now knows that efforts are being made to help fulfil his ambition to "walk again." A dream is becoming more of a reality, for the improvement in results will certainly continue.

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