Discussion Article

Arm Function After Stroke- Can We Make A Difference?

ABSTRACT: Impairment of upper limb function is a significant cause of functional disability after stroke. Based on a review of the literature this paper defines upper limb function and highlights some of the relevant recent developments in neuropathology. The effects of changes in sensation, muscle recruitment and tone are described. Reliable and valid outcome measures of upper limb impairment and disability are listed. The principles of rehabilitation are described in terms of timing of rehabilitation, sensory reeducation, motor control and functional use. Questions are raised regarding the need for counselling for the loss of fine discriminative hand function and for research into this behavioural aspect of upper limb rehabilitation.

L FEARNHEAD[1], CJ EALES[1], VU FRITZ[2]

1 Department of Physiotherapy, University of the Witwatersrand, Johannesburg

2 Department of Neurology, University of the Witwatersrand, Johannesburg

KEYWORDS: STROKE, UPPER LIMB FUNCTION, REHABILITATION.

Loss or limitation of upper limb functional ability is a common result of stroke. Wade (1989) describes the frequent but distressing experience of meeting stroke 'patients nursing their "lost" arm and continually mourning their loss'. Harwood et al (1997) researching the determinants of handicap one and three years after stroke demonstrated the overriding importance of stroke severity (impairment) and disability in determining handicap ('handicap' is defined as the disadvantage resulting from ill-health and is an important measure of outcome in chronic disease). Wyller et al (1997) found that subjective well-being is decreased one year after stroke, and that it was mainly attributed to arm motor impairments.

A study published in 1965 (Bard and Hirschberg) suggested that most upper limb recovery took place within the first three months following the stroke. Duncan et al (1994) concluded that recovery in mild to severely affected patients is almost complete within one month and that more severely affected patients continue to show recovery up to 90 days and even up to six months provided they showed some initial recovery within the first month. However as convincing as these statistics appear to be, in a small study by Taub et al in 1993, selected, motivated chronic stroke patients have demonstrated significant and long lasting improvements in upper limb function after a two week intensive rehabilitation programme. From the results of their controlled trials retraining the sensory function of the hand in stroke patients Yekutiel and Guttman (1993), and Carey et al (1993) concluded that somatosensory deficit can be alleviated even years after stroke.

This discussion paper defines upper limb function and highlights some of the relevant recent developments in neuropathology, measurement and rehabilitation.

CORRESPONDENCE:
Lynn Fearnhead
Physiotherapy Department
University of the Witwatersrand
Johannesburg
7 York Road, Parktown,
2193, South Africa

DEFINITION OF UPPER LIMB FUNCTION:

The primary function of the upper limb is prehension which can be divided into two phases, reach and grasp. Ryerson and Levit (1997) suggest that the key components of upper extremity function include (a) locating a target, requiring the co-ordination of eye-head movements, (b) reaching, involving transportation of the arm and hand in space, (c) manipulation, including grip formation, grasp, and release, and (d) postural control. The coordination between reach and grasp is achieved by a sensorimotor process and is task specific (Marteniuk et al, 1990) e.g. catching a ball is quite different to picking up a glass of water. For precision handling or 'in-hand manipulation' the characteristic muscle contraction is concentric, the pressure applied to the object is light and a major determinant is that the position of the object must change. Precision handling usually involves the index and middle fingers fingers and the thumb (Clarkson and Gilewich 1989).

The hand has other functions. It is a sensory receptor, giving feedback for its own function. The hand also reinforces and trains visual appreciation of shape, texture, space and thickness allowing the central nervous system to recognize objects by touch alone (stereognosis). Secondary functions of the upper limb are for communication, protection, balance and stabilizing for bilateral activities. The appearance of the arm is also important in terms of body image. This must not be underestimated as, according to the psychologist Schilder, 'body image is not a blueprint of geometric relations but has emotional and symbolic significance and lies at the core of the personality' (Heim, 1997).

PATHOLOGY

The specific localization of the infarct i.e. cortex or ascending and descending pathways appears to be critical for recovery - a small lesion in the internal capsule will result in significantly greater disability than a lesion of the same size in the cortex. The role of the pyramidal tract in determining upper limb function has been the subject of intensive research recently. Corticomotorneurons and their descending tracts play an essential role in precise distal hand function. Experiments conducted on monkeys demonstrated little gross movement deficit soon after complete section of the pyramidal tracts bilaterally. The monkeys were able to sit, run and climb in their cage with their head erect. However although they were able to use a power grip, they exhibited substantial deficits in the control of fine independent finger movements (Rothwell 1994). Bastings et al (1997) using motor evoked potentials to measure conduction in central motor pathways concluded that hand motor recovery will not occur after infarct i.e. the hand will not respond to motor retraining, unless there is a measurable conduction velocity through a damaged but still functional pyramidal tract.

Researching the effects of cortical infarct Nudo et al (1996) found that after local damage to the hand section of the motor cortex of adult primates "rehabilitative training can shape subsequent reorganization in the adjacent intact cortex"- the surrounding undamaged cortex learned to control the movements the monkeys had lost through the experimental damage. This is in keeping with research by Byl and Melnick (1997) in which progressively more refined and differentiated cortical representation of skin, muscle, joint afferents and motor movements are described in the cortical hand areas following specific training. It appears that a certain amount of neural plasticity can occur within the damaged sensorimotor cortex in response to functional need or retraining.

IMPAIRMENT

Sensory loss as well as loss of more complex perceptual functions (higher-order motor planning and the formation of action plans) has been found to be a factor contributing to inferior levels of functional recovery as well as longer rehabilitation in several studies (Carey et al 1993). After losing sensation patients tend to develop a learned disuse phenomenon that leads to a further deterioration of motor ability. Sensation of the glabrous skin of the pad of the thumb and the tips of the fingers is particularly important for hand function.

There is evidence that muscle weakness, due to inadequate agonist recruitment and reduced firing rates of motor neurons, plays a dominant role in the disturbance of all active voluntary movement (Fellows et al 1994). However as Rothwell (1994) states 'the major problem facing the motor control system is not only to contract the agonist, or the prime moving muscle by the correct amount and at the appropriate time but also to time and organize the pattern of agonist, fixator and postural muscle contractions which are necessary to accompany its action'.

Although the extent to which spasticity impairs upper limb function is unknown, it is seen clinically that undue effort e.g. in walking or using the affected or unaffected upper limb, can result in the reinforcement of stereotyped abnormal patterns of movement which then prevent functional skilled movements particularly of the hand (Bobath, 1990).

It is also accepted that some of the resistance of a muscle to lengthening is due to changes in the intrinsic properties of the muscle fibres themselves. Muscles held in the lengthened position will gain sarcomeres whilst those in the shortened position lose sarcomeres thus changing the normal resting length of the muscle. This can make a significant difference functionally e.g. it is particularly important at the wrist joint to maintain the position best adapted for grasp i.e. 40-45 degrees of wrist extension and 15 degrees of ulnar deviation. This is the position of maximum efficiency of the muscles of the fingers especially the flexors (Kapandji 1982).

The relative immobilization following stroke produces viscoelastic changes in connective and neural tissue structures that in turn compromise normal movement.

MEASUREMENT

An important aspect of the research relating to stroke has been the development of valid and reliable measurement tools of impairment, activities and participation in life situations.

It is essential to choose a measure that can detect the change expected from the process and outcome of rehabilitation e.g. the measurement of grip strength is a very sensitive single measure after stroke (Heller et al, 1987). Sunderland et al (1989) described a correlation between grip strength and the degree of functional motor capacity according to several outcome measures (Motricity Index, Motor Club Assessment, Frenchay Arm Test, 9-Hole Peg Test). The Modified Ashworth Scale is commonly used to assess muscle tone (Bohannon and Smith 1987). The Barthel Index and the FIM have been criticized for not being specifically sensitive to upper limb disability (Feys et al, 1998) although they are both valid, reliable measures of stroke outcome.

There are a number of tests of movement and function that include sections for the upper limb. The Motricity Index, the Brunnstrom- Fugl-Meyer test, the Motor Assessment Scale, the Rivermead Motor Assessment, the Nine Hole Peg test and the Chedoke-McMaster Stroke Assessment are fully described in 'Physical Rehabilitation Outcome Measures' (1994) or ' Measurement in neurological rehabilitation' (Wade, 1992).

REHABILITATION

A personal definition of rehabilitation has the power to focus and direct therapy and while there are numerous definitions of rehabilitation, the following, by Wade (1993) is comprehensive and in accordance with the World Health Organizations 1998 ICIDH-2 classification of impairment, activities and participation. 'Rehabilitation should aim:

a) to maximize the patient's role fulfillment and his independence in his environment, all within the limitations imposed by the underlying pathology and impairments and by the availability of resources.

b) to help the person to make the best adaptation possible to any difference between the roles achieved and the roles desired'. This is particularly important in upper limb rehabilitation as skilled hand function frequently cannot be achieved.

TIMING OF REHABILITATION

Ernst (1990) in his review of physiotherapy and stroke rehabilitation suggested that "studies aimed at clarifying the issue of optimal rehabilitation should begin therapy in the very early phase after the acute event". Although there is no hard evidence to support a better functional outcome if active therapy is begun early it is generally accepted that early therapy is important to maintain the biomechanical alignment necessary for potential recovery and to prevent complications such as subluxation of the glenohumeral joint, shoulder-hand syndrome, and shoulder pain.

There is evidence that suppression of movement or 'learned disuse' can occur post stroke (Taub et al, 1993). The cause of this is explained in terms of diaschisis - the functional depression of intact neurons in regions remote from damaged neurons although anatomically connected. The implication is that rehabilitation can only occur after resolution of this shock-like state (weeks or months in monkeys).

SENSORY RE-EDUCATION

A five stage sensory re-education programme has been devised by Nakada and Uchida (1997) which can be used as a guideline for stroke hand rehabilitation. The stages are;

1) Feature detection and recognition of objects, vision occluded,
2) Correction of the pattern of prehension of the hand,
3) Control of precise force for grasping objects,
4) Maintenance of grasping force during movements of more proximal joints,
5) Manipulation of objects.

Yekutiel and Guttmann(1993) in their study of sensory function emphasized use of sensory tasks which the patient can do and which he finds interesting, to promote learning. They also used vision and the 'good' hand to teach tactics of perception.

MOTOR CONTROL

Butefisch et al (1995) measured the effects of a stereotyped repetitive active training programme of the affected hand in 27 patients using a multiple baseline approach across individuals. They achieved a significant improvement in grip strength and the Rivermead Motor assessment score. Hummelsheim et al (1997) compared the use of suprathreshold electrical stimulation of wrist muscles with the same training programme used by Butefisch in a small group of stroke patients. Only the repetitive training programme produced a significant improvement in the movement parameters. They ascribe the improvement being due to the proprioceptive and cutaneous impulses generated repetitively and time-locked to the voluntary movement as being the basis for motor learning.

A study by Feys et al (1998) to investigate the effects of a specific therapeutic intervention on arm function in the acute stage after stroke only found motor recovery to be significantly better in the experimental group and ascribed this to the repetitive stimulation of muscle activity in the arm. The therapeutic implication of these studies is that interventions should be directed at recruitment of muscle activity.

Other strategies have been used in an attempt to improve motor function for example, EMG biofeedback (Moreland and Thomson 1994), rapid brushing and vibration. Results of trials using these techniques has not consistently demonstrated their value in rehabilitation. (Good, 1994). Neuromuscular stimulation has been used effectively to reduce hand oedema after stroke (Faghri, 1997) and there is some evidence that it enhances upper limb motor recovery of acute stroke survivors (Chae et al, 1998).

FUNCTIONAL USE

It is generally accepted and research has demonstrated that many stroke survivors have considerably more motor ability available than they make use of. (Taub et al, 1993; Rohrs and Graham 1996). In this latter study all subjects had a Brunnstrom stage 5-6 or 6 classification implying that they could perform normal movement patterns. However their quality of movement was affected by speed, complexity and co-ordination components. Patients had difficulty with activities such as handling money, fastening a buckle, manipulating pegs and lacing a shoe.

In the studies by Wolf et al (1989) and Taub et al (1993) using strategies to overcome the learned disuse of the hemiplegic arm in chronic stroke patients Wolf and co-workers only restrained the unaffected upper limb. In Taub's small study they combined restraint of the unaffected limb with an intensive 14 day retraining programme for the affected upper limb. There are two facts of particular note in this research. Firstly the significant movement gains were maintained during a two year follow-up period and secondly a key selection criterion was that patients, seated with the forearm supported, had to demonstrate 20 degrees of active extension at the wrist joint and 10 degrees extension at the metacarpo-phalangeal and proximal interphalangeal joints respectively. This could be used to identify chronic patients who may benefit from intensive short term rehabilitation.

Taub's research suggested that the deficit can be minimized by inhibiting the unaffected upper limb (restraint) combined with intensive practice of functional movement with the impaired limb.

SUMMARY

Through the research that has been devoted to the functional recovery of the upper limb after stroke in recent years the following components in the rehabilitation process have been identified.

- Measurement - sensori-motor, function.
- Goal setting with the patient and team.
- Prevention of complications (therapy and self-responsibility) - maintenance of range of movement, prevention of pain and gleno-humeral subluxation.
- Sensory re-training - discriminative, vision occluded, functional activity.
- Motor re-training - muscle recruitment, repetition, reach and grasp, manipulation.
- Functional reintegration - task orientated, sensorimotor, repetition.

Specific rehabilitation programmes based on these components still need to be developed and researched with the emphasis on measurement of functional outcome, however there are indications that discriminative sensory re-education, movement repetition and short intensive programmes may be particularly important factors.

It appears essential that we revise the common clinical practice of the physiotherapist treating the patients shoulder and arm with the occupational therapist treating the hand to one of more shared responsibility for both reach and grasp.

If it becomes evident that there is a poor prognosis for recovery of fine discriminative hand function i.e. there is no improvement in sensorimotor function at six weeks post stroke or a month after starting therapy according to the programme outlined above, the focus of rehabilitation should shift towards the secondary functions of the upper limb and counselling for the loss of fine discriminative hand function must be considered. What is the best way of helping our patients come to terms with this loss? Will patient education help? Is 'time the only healer'? This behavioural aspect has received little attention in the literature. This must be rectified if we are to minimize the gap between 'roles achieved and roles desired' in terms of upper limb function for the majority of our stroke patients. ❑

REFERENCES

Bastings EP, Rapisarda G, Pennisi G, et al 1997 Mechanisms of hand motor recovery after stroke: an electrophysiologic study of central motor pathways. Journal of Neurological Rehabilitaton 11: 97-108

Bobath B 1990 Adult hemiplegia : Evaluation and treatment. 3rd edition London Heinemann

Bohannon R, Smith M 1987 Inter-rater reliability of a Modified Ashworth Scale of muscle spasticity. Physical Therapy 67: 206-207

Butefisch C, Hummelsheim H, Denzler P, Mauritz K-H 1995 Repetitive training of isolated movements improves the outcome of motor rehabilitation of the centrally paretic hand: Journal of the Neurological Sciences 130: 59-68

Byl NN, Melnick M 1997 The neural consequences of repetition: clinical implications of a learning hypothesis. Journal of Hand Therapy 10: 160-174

Carey LM, Matyas TA Oke LE 1993 Manual stretch: Sensory loss in stroke patients: effective training of tactile and proprioceptive discrinination.Archives of Physical Medicine and Rehabilitation 74: 602-611

Chae J, Bethoux F, Bohinc T, et al. 1998 Neuromuscular stimulation for upper extremity motor and functional recovery in acute hemiplegia. Stroke 29: 975-979

Clarkson HM, Gilewich GB 1989 Musculoskeletal assessment, joint range of motion and manual muscle strength, Williams and Wilkins

Cole B, Finch E, Gowland C, Mayo N 1994 Physical Rehabilitation Outcome Measures. The Canadian Physiotherapy Association, Toronto, Canada.

Duncan PW, Goldstein LB, Horner RD1994 Similar recovery of upper and lower extremities after stroke. Stroke 25: 1181-1188

Ernst E 1990 A review of stroke rehabilitation and physiotherapy. Stroke 21: 1081-1085

Faghri PD 1997 The effects of neuromuscular stimulation- induced muscle contraction versus elevation on hand edema in CVA patients. Journal of Hand Therapy 10: 29-34

Fellows SJ, Kaus C, Thilmann AF 1994 Voluntary movement at the elbow in spastic hemiparesis. Annals of Neurology 366: 397-407

Feys HM, De Weerdt WJ, Selz BE et al 1998 Effect of a therapeutic intervention for the hemiplegic upper limb in the acute phase after stroke. Stroke 29: 785-792

Good DC 1994 Treatment strategies for enhancing motor recovery in stroke rehabilitation. Journal of Neurological Rehabilitation 8: 177-186

Gowland C, deBruin H, Basmajjian JV, et al 1992 Agonist and antagonist during voluntary upper-limb movement in patients with stroke. Physical Therapy 72: 624-633

Harwood RH, Gompertz P, Pound P, Ebrahim S 1997 Determinants of handicap 1 and 3 years after a stroke. Disability and Rehabilitation 19(5): 205-211

Heim 1997 Why want a deformed, anaesthetic , functionless hand? Disability and Rehabilitation 19(2): 56-63

Heller A, Wade DT, Wood VA, Sunderland A, Langton Hewer R, Ward E 1987 Arm function after stroke : measurement and recovery over the first three months. Journal of Neurology, Neurosurgery and Psychiatry 50: 714-19

Hummelsheim H, Maier-Loth ML, Eickhof C 1997 The functional value of electrical muscle stimulation for rehabilitation of the hand in stroke patients. Scandinavian Journal of Rehabilitation Medicine 29: 3-10

Kapandji IA. 1982 The physiology of the limbs: volume one upper limb. Edinburgh. Churchill Livingstone

Moreland J,Thomson MA 1994 Efficacy of electromyographicbiofeedback compared with conventional physical therapy for upper-extremityfunction in patients following a stroke: a research over-view and meta-analysis. Physical Therapy 74: 534-547

Nakada M, Uchida H 1997 Case study of a five stage sensory\ reeducation program. Journal of Hand Therapy 10: 232-239

Nudo RJ, Wise BM, Siuentes F, Milliken GW 1996 Neural substrates for the effectsof rehabilitative training on motor recovery after ischaemic infarct. Science 273: 1791-1795

Rohrs C, Graham M. 1996 The functional use of the affected hand in hemiplegic hands at Brunnstrom stage 6. South African Journal of Occupational Therapy. November: 39-45

Rothwell J 1994 Control of human voluntary movement. London Chapman and Hall

Sunderland A, Tinson DJ, Bradley EL, Langton Hewer R 1989 Arm function after stroke. An evaluation of grip strength as a measure of recovery and a prognostic indicator. Journal of Neurology, Neurosurgery and Psychiatry 52: 1267-1272

Taub E, Miller NE, Novack TA, Cook III EW, Fleming WC, Nepomuceno CS, Connell JS, Crago JE 1993 Technique to improve chronic deficit after stroke. Archives of Physical Medicine and Rehabilitation 74: 347-54

Wade DT 1989 Measuring arm impairment and disability after stroke. International Disability Studies 11: 89-92

Wade DT 1992 Measurement in neurological rehabilitation. Oxford University Press

Wade DT 1993 Acute stroke: treatment and rehabilitation. Hospital Update. October: 42-48

Wyller TB, Sveen U, Sodring KM et al 1997 Subjective well being after stroke. Clinical Rehabilitation 11: 139-145

Yekutiel M, Guttman E 1993 A controlled trial of the sensory function of the hand in stroke patients. Journal of Neurology, Neurosurgery and Psychiatry 56: 241-244