2. Brain Reorganization, Recovery and Organized Care

Robert Teasell MD, Norhayati Hussein MBBS MRehabMed

2.1 Important Principles of Rehabilitation

2.1.1 Neurological Recovery

Recovery after a stroke is associated with cortical reorganization. Motor recovery is a complex process combining:

1. **Neurological or Spontaneous Recovery.** Recovery of impairment or normal way of moving as measured by Fugl-Meyer score or 3D Kinematics (restoration of normal movement patterns).

2. **Functional Recovery.** Recovery of tasks or activities often through learned compensatory movements (new movement patterns) as measured by the ARAT, Barthel Index or even the FIM. Both involve changes to the motor cortex and this relationship is not fully understood.

**Spontaneous or Intrinsic Neurological Recovery**

Neurological recovery is defined as recovery of neurological impairments. These are determined primarily by the site and extent of the stroke. As a general rule, the severity of the initial deficit is inversely proportional to the prognosis for recovery. The majority of neurological recovery occurs within the first 1-3 months. Afterwards recovery may occur much more slowly for up to one year. The course of recovery is a predictable phenomenon; it is initially very rapid and then negatively accelerates as a function of time (Skilbeck et al. 1983). Skilbeck et al. (1983) studied 92 stroke survivors with a mean age of 67.5 years (range= 36-89) at final assessment, either 2 or 3 years after stroke. The majority of recovery was reported within the first 6 months, with continued but non-statistically significant recovery after 6 months. This type of recovery is still largely if not completely independent of rehabilitation and is discussed further later on.

**Functional or Adaptive Recovery**

Functional deficits are often referred to as disabilities and are measured in terms of functions such as activities of daily living. Functional recovery is defined as improvement in mobility and activities of daily living; it has long been known that it is influenced by rehabilitation. This recovery depends on the patient's motivation, ability to learn and family supports as well as the quality and intensity of therapy. Functional recovery is highly influenced by neurological recovery but is not dependent on it.

2.1.2 Time Course of Recovery

Peak neurological recovery from stroke occurs within the first one to three months. A number of studies have shown that recovery may continue at a slower pace for at least 6 months; with up to 5% of patients continuing to recover for up to one-year. This is especially true with patients who are severely disabled at the time of initial examination (Bonita and Beaglehole 1988, Duncan et al. 1992, Ferrucci et al. 1993, Kelly-Hayes et al. 1989, Wade et al. 1983, Wade et al. 1987; see discussion below).

Progress towards recovery may plateau at any stage of recovery with only a very small percentage of those with moderate to severe strokes (about 10%) achieving “full recovery”. The return of motor power is not synonymous with recovery of function; function may be hampered by the inability to perform skilled
coordinated movements, apraxias, sensory deficits, communication disorders as well as cognitive impairment. Functional improvements may occur in the absence of neurological recovery (Duncan and Lai 1997, Nakayama et al. 1994). Functional recovery (the ability to do activities despite limitations) and improvement in communication may continue for months after neurological recovery is complete.

2.2 Mechanisms of Neurological Recovery

Neurological recovery is defined as recovery of neurological impairments and is often the result of a number of factors listed below.

2.2.1 Processes of Neurological Recovery

Processes leading to initial clinical improvement occur independent of behaviour or stimuli, although there is some concern about too aggressive very early mobilization (AVERT 2015). Processes which may account for neurological recovery include: 1) Resolution of post-stroke edema; 2) Reperfusion of the ischemic penumbra; 3) Resolution of diaschisis.

Post-Stroke Edema
Edema surrounding the lesion may disrupt nearby neuronal functioning. Some of the early recovery may be due to resolution of edema surrounding the area of the infarct (Lo 1986) and as the edema subsides, these neurons may regain function. This process may continue for up to 8 weeks but is generally completed much earlier (Inoue et al. 1980). Cerebral hemorrhages tend to be associated with more edema, which take longer to subside, but which may in turn be associated with a more dramatic recovery.

Reperfusion of the Ischemic Penumbra
Reperfusion of the ischemic penumbra is another local process which can facilitate early recovery. A focal ischemic injury consists of a core of low blood flow which eventually infarcts (Astrup et al. 1981, Lyden and Zivin 2000), surrounded by a region of moderate blood flow, known as the ischemic penumbra (Astrup et al. 1981, Lyden and Zivin 2000), which is at risk of infarction but is still salvageable. Reperfusion of this area causes affected and previously non-functioning neurons to resume functioning with subsequent clinical improvement.
The AVERT (2015) trial, looking at very early mobilization of the acute stroke patient, raised concerns about the penumbra and worsening or extension of the stroke.

**Diaschisis**

Diaschisis is a state of low reactivity or depressed function as a result of a sudden interruption of major input to a part of the brain remote from the site of brain damage. With injury to one area of the brain, other areas of brain tissue are suddenly deprived of a major source of stimulation. Nudo et al. (2001) noted that diaschisis occurs early after injury and is an inhibition or suppression of surrounding cortical tissue or of cortical regions at a distance that are interconnected with the injury core. The reversibility may be partially due to the resolution of edema, which may account for a portion of spontaneous recovery (Nudo et al. 2001). Neuronal function may return following the resolution of diachisis, particularly if the connected area of the brain is left intact. This is particularly true of non-cortical structures after cortical injury (Lo 1986).

**Proportional Recovery of Upper Limb Impairment**

Within 6 months upper limb impairment resolves by fixed proportion. Fixed proportion means that 70% of each patient’s maximum possible improvement occurs regardless of the initial impairment (for instance, as measured by the Fugl-Meyer score), but only for those with relatively intact corticospinal (motor) tract functioning (Prabhakaran et al. 2008). This holds true for patients across all ages and countries with different rehabilitation services (Byblow et al. 2015).

Proportional recovery or resolution of upper extremity impairment post stroke is dependent on corticomotor tract integrity. Motor evoked potentials (MEPs) early post stroke is associated with recovery outcomes (Stinear et al. 2010). Irreversible structural damage to the corticospinal tract severely limits recovery of upper limb movement (Stinear et al. 2007; 2010). This recovery is unaffected or minimally affected by rehabilitation therapy. 3D kinematics in subacute and chronic stroke survivors have shown that motor recovery associated with rehabilitation is driven more by adaptive or compensatory learning strategies. Most of the tests that we use clinically only assess a patient’s ability to accomplish a certain function or task; we do not tend to measure function.

### 2.2.2 CNS Reorganization (Later Recovery)
Neurological reorganization plays an important role in the restoration of function. It can extend for a much longer period of time than local processes, such as the resolution of edema or reperfusion of the penumbra, and is of particular interest because it can be influenced by rehabilitation training. Nudo (2003a), based on animal research, has suggested that changes occurring during motor learning (i.e. synaptogenesis and increases in synaptic strength), are likely the same type of changes that occur during this part of recovery from stroke. This has been well shown after small, focal lesions in the motor cortex where the same principles of motor learning and development of functional connections are occurring in adjacent, undamaged tissue.

**In Normal Individuals**
Cramer (2003) notes that, “in normal right-handed persons, performance of a unilateral motor task by the right hand is associated with activation that is largely contralateral, with brain activity ipsilateral to the active hand being small by comparison (Kim et al. 1993). In contrast, there is greater ipsilateral activation for movements by the left hand.”

**In Individuals Post Stroke**
Nudo (2003a) reports that neuroplasticity post-stroke (with damage to the motor cortex as an example) is based on three main concepts:

1. In normal (non-stroke) brains, acquisition of skilled movements is associated with predictable functional changes within the motor cortex.
2. Injury to the motor cortex post-stroke results in functional changes in the remaining cortical tissue.
3. After a cortical stroke, these two observations interact so that reacquiring motor skills is associated with functional neurological reorganization occurring in the undamaged cortex (Nudo 2003a).

**Mechanism of Reorganization**
Cramer (2003) noted that after a stroke in humans, movement of the affected hand resulted in three patterns of cortical reorganization that were not mutually exclusive of each other and which may occur concomitantly:

1. A greater degree of bilateral motor cortex activity was seen with recruitment of the motor network of the ipsilateral (unaffected hemisphere; Cramer 2003). In fact, there is widespread areas of cortical hyperactivity occurring days post stroke and dimishing within months of the stroke onset. Non-stroke (less affected) hemisphere cortical activity decreases over months post stroke in those patients who show a good motor recovery but not in those who do not show a good motor recovery.
2. There was increased recruitment of secondary cortical areas such as supplementary motor area (SMA) and pre-motor cortex in the contralateral (affected) hemisphere (Cramer 2003). Recruitment along the cortical rim of the infarct was seen (Cramer 2003). Reorganization of the brain after a stroke is dependent not only on the lesion site, but also on the surrounding brain tissue and on remote locations that have structural connections with the injured area. Following a stroke, brain reorganization in response to relearning motor activities, involves primarily the contralateral (affected) hemisphere. Reorganization in response to training occurs along the cortical rim of the infarction with increased recruitment of secondary cortical areas such as supplementary motor area and pre-motor cortex in the contralateral (affected) hemisphere.
3. Ipsilateral cortical involvement is more prominent early on; however, persistence of ipsilateral cortical involvement is generally associated with larger strokes and a poorer recovery.
Therefore, we can note that reorganization of cortex post stroke is dependent on the lesion site but also on remote brain areas with structural connections with the damaged area of the brain. Motor recovery is largely dependent on intact cortex adjacent to the infarct pointing out the importance of preserving penumbral areas.

### 2.3 Predictors of Stroke Recovery

Alexander (1994) noted the two most powerful predictors of functional recovery are initial stroke severity and age. Stroke severity is by far the most predictive factor.

#### 2.3.1 Stroke Severity as Predictor

The best predictor of stroke outcome is initial clinical assessment of stroke severity. This correlates with the length of time to maximal neurological and functional recovery.

Garraway et al. (1981, 1985) first proposed the concept of 3 bands of stroke patients based upon stroke severity during the acute phase:

1. **Mild Strokes**: Few deficits, early FIM score (1st 5-7 days) > 80, Stineman et al. (1998) defined as motor FIM > 62; rehab gains limited by “ceiling” effect.

2. **Moderately Severe Strokes**: Moderate deficits, conscious with significant hemiparesis, early FIM 40-80 or motor FIM 38-62; make marked gains in rehab and 85% discharged to community.

3. **Severe Strokes**: Severe deficits, unconscious at onset with severe paresis or serious medical comorbidity, early FIM < 40 or motor FIM < 37; slower improvement, unlikely to achieve functional independence (unless young) and smallest likelihood of community discharge.

#### Time Course for Recovery Depends on Initial Severity of Impairments

Jorgensen et al. (1995a, 1995b) studied 1,197 acute stroke patients in what is referred to as the Copenhagen Stroke Study. Impairments were classified using the Scandinavian Neurological Stroke Scale (SSS) and functional disability was defined according to the Barthel Index (BI). Neurological recovery occurred on average two weeks earlier than functional recovery. In surviving patients, the best neurological recovery occurred within 4.5 weeks in 80% of the patients, while best ADL function was achieved by 6 weeks. For 95% of the patients, best neurological recovery was reached by 11 weeks and best ADL function within 12.5 weeks. Jorgensen and associates (1995c) reported that best walking function was reached within four weeks for patients with mild paresis of the affected lower extremity, six weeks for those with moderate paresis and 11 weeks for severe paralysis. Consequently, the time course of both neurological and functional recovery was strongly related to both initial stroke severity and functional disability. Jorgensen et al. (1995a, 1995b, 1995c), found two-thirds of all stroke survivors have mild to moderate strokes and are able to achieve independence in ADL.

#### Impairment and Neurological Recovery of Stroke Patients in the Copenhagen Stroke Study

<table>
<thead>
<tr>
<th>Category (SSS)</th>
<th>Admission</th>
<th>Discharge</th>
<th>Survival (%)</th>
<th>Weeks to 80% Best Neurological Recovery</th>
<th>Weeks to 95% Best Neurological Recovery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Severe (0-14)</td>
<td>19%</td>
<td>4%</td>
<td>38%</td>
<td>10</td>
<td>13</td>
</tr>
<tr>
<td>Severe (15-29)</td>
<td>14%</td>
<td>7%</td>
<td>67%</td>
<td>9</td>
<td>15</td>
</tr>
<tr>
<td>Moderate (30-44)</td>
<td>26%</td>
<td>11%</td>
<td>89%</td>
<td>5.5</td>
<td>10.5</td>
</tr>
</tbody>
</table>
Mild/No (45-58) | 41% | 78% | 97% | 2.5 | 6.5
---|---|---|---|---|---
1 Percentage patient distribution on admission, grouped by stroke severity sub groups, as measured by SSS (scores range from 0-58 points).
2 Percentage distribution of survivors (79% of initial group) after completion of stroke rehabilitation.
3 Neurological recovery as measured by SSS.

**Disability and Outcome of Stroke Patients in the Copenhagen Stroke Study**

<table>
<thead>
<tr>
<th>Category (BI)</th>
<th>Discharge</th>
<th>Survival (%)</th>
<th>Weeks to 80% Best Functional Recovery</th>
<th>Weeks to 95% Best Functional Recovery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Severe (0-20)</td>
<td>14%</td>
<td>50</td>
<td>11</td>
<td>17</td>
</tr>
<tr>
<td>Severe (25-45)</td>
<td>6%</td>
<td>92</td>
<td>15</td>
<td>16</td>
</tr>
<tr>
<td>Moderate (50-70)</td>
<td>8%</td>
<td>97</td>
<td>6</td>
<td>9</td>
</tr>
<tr>
<td>Mild (75-95)</td>
<td>26%</td>
<td>98</td>
<td>2.5</td>
<td>5</td>
</tr>
<tr>
<td>No (100)</td>
<td>46%</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

1 Percentage patient distribution on discharge, grouped by stroke severity sub groups, as measured by Barthel Index.
2 Functional recovery as measured by Barthel Index.

Based on these observations one can safely conclude that *the initial severity of the stroke is inversely proportional to the final functional outcome*, with the majority of patients who suffer mild strokes demonstrating no or only mild disabilities, while the majority of patients suffering very severe strokes still experience severe or very severe deficits even after the completion of rehabilitation.

### 2.3.2 Impact of Age on Recovery/Rehabilitation

Recovery is more rapid and occurs to a greater extent in younger individuals with a stroke. This correlates with decline in ability to form neurological connections with aging. There is also a small but significant effect of age on functional recovery.

**Impact of Age in Animal Studies**

In rats, the duration of motor impairment post brain lesion increases with age (Brown et al. 2003). The regenerative response of neurons and glial cells, though largely preserved with age, appears to be delayed or occurs at a diminished rate the older the animal (Popa-Wagner et al. 1999, Whittemore et al. 1985). Reactive neuronal synaptogenesis declines (Scheff et al. 1978), sprouting responses are less robust (Schauwecker et al. 1995, Whittemore et al. 1985) and synaptic replacement rates diminish (Cotman and Andersen 1988). Generally recovery is more rapid and occurs to a greater extent in a younger animal. This correlates with a decline in the rate of formation of new neuronal connections or synaptogenesis in older animals. Older animals do improve post-stroke but it takes longer and occurs to a lesser extent.

**Impact of Age in Clinical Studies**

In a cohort study of 2219 patients, Kugler et al. (2003) studied the effect of patient age on early stroke recovery. The authors found that relative improvement decreased with increasing age: patients younger than 55 years achieved 67% of the maximum possible improvement compared with only 50% for patients above 55 years (p< 0.001). They also found that age had a significant but relatively small impact on the speed of recovery with younger patients demonstrating a slightly faster functional recovery (p< 0.001). The authors concluded that although age had a significant impact it nevertheless was a poor predictor of individual functional recovery after stroke and could not be regarded as a limiting factor in the rehabilitation of stroke patients. However, younger patients did demonstrate a more complete recovery.
In conclusion, in humans, age has a small but significant effect on the speed and completeness of recovery. However, because older stroke patients do recover, albeit at a slower rate, and the overall impact of age is relatively small, age in and of itself is a poor predictor of functional recovery after stroke.

### 2.3.3 Hemorrhagic versus Ischemic Stroke

Approximately 10% of all strokes are due to intra-cerebral hemorrhage (Kelly et al 2003; Paolucci et al 2000; Andersen et al 2009). Hemorrhagic strokes have been associated with more severe neurological deficits and are generally thought to have a higher mortality rate. The apparent poorer outcome among patients with hemorrhagic stroke was attributed to greater initial stroke severity compared to patients with ischemic stroke (Jorgensen et al. 1995). Patients with hemorrhagic strokes have lower functional score upon admission to rehabilitation but tend to fare better in terms of functional gains and achieve higher outcome efficiency scores when compared to those with ischemic strokes. Hemorrhagic strokes are usually admitted to rehabilitation later than ischemic strokes because of greater initial severity.

Lipson et al (2005) studied medical records of 819 consecutive patients with strokes and found that those with a hemorrhagic stroke were admitted to rehabilitation at a significantly later date post stroke with median of 30 days (IQR 15-77) compared to ischemic stroke with median of 18 days (IQR 10.39; p<0.0001). Kelly et al (2003) reported that although the total admission FIM score was lower in patients with hemorrhagic compared to ischemic (51 vs 59, p=0.0001), there was no significant difference in total discharge FIM score between the two groups (79.1 hemorrhagic vs 82.3 ischemic, p=0.2). Patients with ICH gained more FIM points during rehabilitation than ischemic strokes (28 vs 23.3, p=0.002). Hemorrhagic stroke patients with the most severely disabling strokes had significantly greater recovery than ischemic strokes of similar severity.

Paolucci et al (2003) matched patients on the basis of initial stroke severity, age and onset to admission time and found that patients with hemorrhagic strokes demonstrated higher outcome scores at discharge when compared to ischemic strokes. Hemorrhagic patients showed a probability of high therapeutic response on the BI at approximately 2.5 times greater than that of ischemic stroke. The authors attributed the greater gains in hemorrhagic strokes to better neurological recovery associated with resolving brain compression.

### 2.4 Measures of Functional Outcome

#### 2.4.1 Barthel Index

<table>
<thead>
<tr>
<th>Questions</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>What does it measure?</td>
<td>The BI is an index of independence that is used to quantify the ability of a patient with a neuromuscular or musculoskeletal disorder to care for him/herself (regardless of particular diagnostic designations).</td>
</tr>
<tr>
<td>What is the scale?</td>
<td>The index consists of 10 common ADLs, 8 of which represent activities related to personal care while 2 are related to mobility.</td>
</tr>
</tbody>
</table>
What are the key scores? | The index yields a total score out of 100 with higher scores indicating greater degrees of functional independence (McDowell & Newell 1996).
---|---
What are its strengths? | Easy to administer and does not require formal training. Takes little time to complete, which may reduce patient burden. Widespread familiarity contributes to its interpretability.
---|---
What are its limitations? | Relatively insensitive. A lack of comprehensiveness may result in problems with ceiling/floor effects (Duncan et al. 1997). Although many scoring cut-offs have been suggested, there remains a lack of consensus regarding the categorization of BI scores (Roberts & Counsell 1998).

### 2.4.2 Functional Independence Measure

The FIM assesses physical and cognitive disability in terms of level of assistance needed in order for individuals to carry out their daily activities.

#### Functional Independence Measure

<table>
<thead>
<tr>
<th>Questions</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>What does it measure?</td>
<td>Physical and cognitive disability in terms of burden of care – that is, the FIM score is intended to measure the burden of caring.</td>
</tr>
<tr>
<td>What is the scale?</td>
<td>The FIM is a composite measure consisting of 18 items assessing 6 areas of function. These fall into 2 basic domains; physical and cognitive. Each item is scored indicating of the amount of assistance required to perform each item. A simple summed score is obtained determining the level of dependence of the individual. Subscale scores may yield more useful information than combining them (Linacre et al. 1994).</td>
</tr>
<tr>
<td>What are the key scores?</td>
<td>Beninato et al. (2006) determined that 22, 17 and 3 were the change scores for the total FIM, motor FIM and cognitive FIM, respectively, which best separated those patients who had demonstrated clinically important change from those who had not. Each item is scored on a 7-point scale (1=total assistance, 7 = total independence). A simple summed score of 18 – 126 is obtained where 18 represents complete dependence/total assistance and 126 represents complete independence.</td>
</tr>
<tr>
<td>What are its strengths?</td>
<td>The FIM has been well studied for its validity and reliability. FIM is widely used and has one scoring system increasing the opportunity for comparison.</td>
</tr>
<tr>
<td>What are its limitations?</td>
<td>Training and education in administration of the test is necessary (Cavanagh et al. 2000). The use of a single summed raw score may be misleading. Training and education of persons to administer the FIM may represent a significant cost.</td>
</tr>
</tbody>
</table>

#### Functional Independence Measure (FIM) Items

The FIM measures 18 items, each scored from 1-7. There are 13 motor items (motor FIM) and 5 cognitive items (cognitive FIM). The 18 items which make up the FIM are listed below:

- Bladder management
- Bowel management
- Social interaction
- Problem solving
- Memory
- Comprehension
- Bed-to-chair and wheelchair-to-chair transfer
- Toilet transfer
- Tub and shower transfer
- Locomotion (walking or wheelchair)
- Climbing stairs
- Eating
- Grooming
- Bathing
- Dressing (upper body)
2.4.3 Modified Rankin Handicap Scale

The Rankin scale is a global outcomes rating scale for patients post-stroke (Rankin 1957).

Modified Rankin Handicap Scale as an Outcome Measure

<table>
<thead>
<tr>
<th>Questions</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>What does it measure?</td>
<td>The Rankin scale is a global outcomes rating scale for patients post stroke (Rankin 1957).</td>
</tr>
<tr>
<td>What is the scale?</td>
<td>The scale assigned a subjective grade from 1 – 5 based on level of independence with reference to pre-stroke activities rather than on observed performance of specific tasks.</td>
</tr>
<tr>
<td>What are the key scores?</td>
<td>An original Rankin score of 1 indicated no significant disability and 5 the most severe level of disability. Van Swieten et al. (1988) expanded the ranking system to include 0; no symptoms.</td>
</tr>
<tr>
<td>What are its strengths?</td>
<td>The Modified Rankin Scale is an extremely simple, time efficient measure. Feasible for use in large centers or large trials (Wade 1992; de Haan et al. 1995). The MRS requires no special tools or training.</td>
</tr>
<tr>
<td>What are its limitations?</td>
<td>The categories within the scale are broad and poorly defined (Wilson et al. 2002). The use of dichotomization to classify global outcome may be associated with a loss of information with regard to benefits derived from any rehabilitation intervention.</td>
</tr>
</tbody>
</table>

Modified Rankin Handicap Scale

<table>
<thead>
<tr>
<th>Rankin Grade</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No Symptoms</td>
</tr>
<tr>
<td>1</td>
<td>No significant disability despite symptoms; able to carry out all usual duties and activities</td>
</tr>
<tr>
<td>2</td>
<td>Slight disability: unable to carry out all previous activities but able to look after own affairs without assistance.</td>
</tr>
<tr>
<td>3</td>
<td>Moderate disability: requiring some help, but able to walk without assistance</td>
</tr>
<tr>
<td>4</td>
<td>Moderately severe disability: unable to walk without assistance, and unable to attend to own bodily needs without assistance</td>
</tr>
<tr>
<td>5</td>
<td>Severe disability: bedridden, incontinent, and requiring constant nursing care and attention</td>
</tr>
</tbody>
</table>

(Ref: van Swieten et al. 1988)

Organized Stroke Care – Interdisciplinary Care/Team

2.5 Efficacy of Stroke Rehabilitation

Stroke rehabilitation improves functional outcomes (especially in moderately severe strokes) and reduces mortality (especially in more severe strokes).

Stroke rehabilitation is challenging for a number of reasons:

• Multiple impairments, several domains
• Interaction between impairments
• Different speed of recovery
• Several disciplines and agencies involved
• Staged interventions, therapy input
• Personal, environment and support
• Complex interdisciplinary process

2.5.1 Principles of Organised Management

• Patient focused multidisciplinary approach
• Collaborative policy
• Comprehensive assessments
• Coordinated delivery of treatments
• Staff training & education
• Involvement of patients & carers

Comprehensive Stroke Rehab Programs Include:
• Continuity of care
• Experienced interdisciplinary team
• Careful attention to co-morbidities and complications
• Early goal-directed treatment
• Systematic assessment of progress
• Education
• Attention to psychosocial issues
• Early comprehensive discharge planning

HIGHLIGHTED STUDY

Methods: 29 trials (6536 patients) underwent a meta-analysis.
Results: Mortality at 1 year 0.86 (0.71-0.94); Death or dependence 0.78 (0.68-0.89); Death or institution 0.80 (0.71-0.90). This was independent of age and gender.

<table>
<thead>
<tr>
<th>Type of Stroke Unit</th>
<th>Admission</th>
<th>Discharge</th>
<th>Features</th>
<th>Efficacy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acute, intensive</td>
<td>Acute (hours)</td>
<td>Days</td>
<td>High nurse staffing Life support facilities</td>
<td>No trials</td>
</tr>
<tr>
<td>Acute, semi-intensive</td>
<td>Acute (hours)</td>
<td>Days</td>
<td>Close physiological monitoring</td>
<td>Better than non-specific stroke care</td>
</tr>
<tr>
<td>Combined Acute-Subacute</td>
<td>Acute (hours)</td>
<td>Days–weeks</td>
<td>Acute care/rehabilitation Conventional staffing</td>
<td>Better than non-specific stroke care and rehab</td>
</tr>
<tr>
<td>Subacute Rehab</td>
<td>Delayed</td>
<td>Weeks</td>
<td>Rehabilitation</td>
<td>Better than non-specific stroke rehab</td>
</tr>
<tr>
<td>Mobile Rehab (SWAT) team</td>
<td>Variable</td>
<td>Days-weeks</td>
<td>Medical / rehabilitation advice</td>
<td>No better than non-specific stroke rehab</td>
</tr>
</tbody>
</table>
Mixed Neuro-rehabilitation | Variable | Weeks | Mixed patient group Rehabilitation | Better than non-specific stroke rehab
---|---|---|---|---

Subacute Stroke Rehab Units (Foley et al. 2007) result in:
- 10 day reduction in inpatient stay
- 1 in 27 patients treated will not need institutionalization
- Increased functional outcomes with decrease in informal care costs

Stroke units improve outcomes by:
- Greater attention to stroke specific medical, nursing and therapy processes
- Greater involvement of caregivers
- Fewer stroke related complications
- Greater and earlier functional recovery
- Expedited hospital discharges
- Specialized interdisciplinary care

**HIGHLIGHTED STUDY**

**Methods:** Prospective RCT of 311 consecutive moderately severe acute stroke patients, admitted within 7 days of stroke onset and randomized to either stroke unit or general medical unit.

**Results:** A greater proportion of stroke unit patients were classified as independent when compared to medical unit patients, 50% vs. 32% at 60 days; when comparing survivors the proportion of independent patients rose to 62%. Follow-up at one year found no longer significant differences in proportion of patients deemed independent between groups.

**HIGHLIGHTED STUDY**

**Methods:** Stroke patients who were deemed in need of rehabilitation (n=251) were randomized to Rehab Unit (n=127) or Community Care (n=124) after an average of 10 days in acute care.

**Results:** Rehab Unit LOS was a mean of 27.8 days. Of those admitted to Community Care, 40% went to a nursing home, 30% to outpatient therapy and 30% to no formal rehab treatment. At 7 month follow-up for all stroke patients, 23% of the Rehab Unit patients vs. 38% of the Community Care patients were dependent (BI < 75) or dead (p=.01), a 39% reduction in worse outcomes with stroke rehab care. For moderate to severe stroke patients (Barthel Index <50 at time of admission; n=114), 32% of the Rehab Unit patients vs. 62% of the Community Care patients were dead or dependent 7 months post stroke (p=.002), a 48% reduction in worse outcomes with stroke rehab care for more severe stroke patients. Of all the stroke patients in the study, the Barthel Index score was 90 in the Stroke Rehab Unit group and 73 in the Community Care group. Milder stroke patients (Barthel Index >50 at time of admission; n=137) did not improve any more in the Stroke Rehab Unit than in the Community Care Unit indicating these patients can be rehabilitated in the community.

**HIGHLIGHTED STUDY**


**Methods:** 220 acute (within 7 days) stroke patients were randomized to either a combined acute/rehabilitation stroke unit or a general medical unit.

**Results:** Patients who were treated on the combined stroke unit were more likely to have been discharged home, were less likely to have been institutionalized and were more likely to have higher Barthel Index scores at 6 weeks and 1 year. The 6 week mortality for patients treated on the combined stroke unit was lower. 5 and 10 year follow-up found a greater proportion of patients originally treated on the stroke unit were alive, residing at home with higher Barthel Index scores. Significant benefit was still seen at 10 years.

**HIGHLIGHTED STUDY**


**Methods:** 245 stroke patients randomized at 2 weeks post stroke to a rehabilitation unit or a general medical unit after stratification by stroke severity.

**Results:** Patients with a poor prognosis treated on a general medical ward had higher mortality and longer hospital stays. Patients in the stroke rehab unit with intermediate severity of stroke had better discharge Barthel Index scores and shorter hospital stays.

**Figure. The Impact of Stroke Unit Care on Combined Death/Dependency Post Stroke (Foley et al. 2007)**

<table>
<thead>
<tr>
<th>Study or sub-category</th>
<th>Treatment</th>
<th>Control</th>
<th>Ratio OR</th>
<th>Weight</th>
<th>Ratio OR</th>
</tr>
</thead>
<tbody>
<tr>
<td>O1 Acute stroke care vs. Alternative care</td>
<td>103/271</td>
<td>110/373</td>
<td>16.86</td>
<td>0.94</td>
<td>1.331</td>
</tr>
<tr>
<td>O2 Combined acute and rehabilitation services</td>
<td>162/152</td>
<td>62/120</td>
<td>9.64</td>
<td>0.49</td>
<td>0.76</td>
</tr>
<tr>
<td>O3 Post acute rehabilitation vs. Alternative care</td>
<td>9/23</td>
<td>10/69</td>
<td>1.48</td>
<td>0.60</td>
<td>1.90</td>
</tr>
</tbody>
</table>

**Figure. The Impact of Stroke Unit Care on Combined Death/Dependency Post Stroke (Foley et al. 2007)**
Elements of Stroke Rehabilitation

2.6 The Earlier the Better

The brain appears to be “primed” to “recover” early in post-stroke period. Animal studies suggest there is a time window when brain is “primed” for maximal response to rehab therapies, such that delays are detrimental to recovery (Biernaskie et al. 2004). The effects of training after stroke are generally greater when started early after stroke, perhaps because it takes advantage of the “sensitive period” of enhanced neuroplasticity. There has long been a clinical association between early admission to rehab and better outcomes (Paolucci et al. 2000; Salter et al. 2006; Bai et al. 2012).

2.6.1 Benefit of Early Therapy in Animals

Animal studies indicate early rehab is associated with improved recovery; later rehab is not.

**HIGHLIGHTED STUDY**


**Methods:** Rats suffered an induced small motor stroke and were then subjected to rehab for 5 weeks beginning at 5, 14 and 30 days or control group (social housing) post stroke. Rehab consisted of weeks of enriched environment.

**Results:** The group that got rehab day 5 post admission showed marked improvement, the day 14 group showed moderate improvement and the day 30 group showed no improvement when compared to controls. The animals were subsequently autopsied and there was corresponding cortical reorganization in brain around stroke.

2.6.2 Clinical Evidence for Early Therapy

In clinical studies, earlier rehabilitation is associated with better functional outcomes with reduced formal and informal care needs.

**HIGHLIGHTED STUDY**


**Methods:** A case controlled study of 135 stroke patients who received: 1) Rehabilitation within the first 20 days post stroke (short onset); 2) rehabilitation 21 to 40 days post stroke (medium onset); 3) rehabilitation 41 to 60 (long onset) post stroke; all patients received the same physical therapy program.

**Results:** Higher dropout rate was noted in the short onset group. Barthel Index scores in the short onset group showed significantly greater rate of improvement than the other 2 groups.

**HIGHLIGHTED STUDY**

Methods: 435 patients admitted to an inpatient stroke rehab program within 150 days of a first unilateral stroke. Patients admitted early to rehab were compared to those who were admitted later.

Results: FIM scores at admission and discharge as well as FIM change and FIM efficiency were significantly higher for early admission than for delayed admission patients. Length of stay was significantly longer among delayed admission patients.

While the strong association between early admission and improved functional outcomes appears to be causal, stroke severity might have confounded the relationship as the above studies are not RCTs. Patients who had suffered more severe strokes (with higher levels of impairment) were also more likely to have suffered medical complications or have been too impaired initially to be able to actively participate in rehabilitation, while patients with mild to moderate strokes, or those considered to be the best rehabilitation candidates were likely admitted to rehabilitation sooner. Clinical Practice Guidelines (Duncan et al. 2005) “recommend that rehabilitation therapy start as early as possible, once medical stability is achieved”. The AVERT trial is the first RCT to explore the importance of early rehabilitation. This suggests that mobilization in the first few days must be carefully done.

HIGHLIGHTED STUDY

Methods: Patients less than 24 hrs post stroke were randomly assigned to Standard Care (SC) or Standard Care and Very Early Mobilization (VEM) until discharge or 14 days post stroke onset. This was a multi-centered 56 site international RCT across 5 countries which took 8 years.

Results: 2104 patients were randomized; 1054 in the VEM group and 1050 in the Usual Care group. The VEM group started earlier (18.5 vs. 22.5 hrs post stroke), got more out of bed sessions (6.5 vs. 3.0) and received more therapy (31 minutes/day; total 201 minutes vs. 10 minutes/day; total 70 minutes). More patients in the Usual Care (n=525) than VEM (n=480) (p=0.001) had favourable outcomes (modified Rankin Scale [0-2] at 3 months post stroke). 72 patients (7%) in Usual Care vs. 88 patients (8%) VEM died; 19 vs. 31 died of stroke progression.

2.7 Intensity: More is Better

Post-stroke rehabilitation increases motor brain reorganization, while lack of rehabilitation reduces reorganization. More intensive motor training in animals further increases brain reorganization. The greater the intensity of therapies clinically, the better the outcomes; this has been reported for physiotherapy, occupational therapy, aphasia therapy, treadmill training and upper extremity function in selected patients (i.e. CIMT). There appears to be a dose-response relationship. The study of Kalra (1994) below indicates the benefit of frontloading of therapy in terms of outcomes and cost efficiency.

HIGHLIGHTED STUDY

Methods: This study randomized 146 “middle band” strokes to stroke unit (SRU) or general medical unit (GMU) care.

Results: The median Barthel Index score was 4/20 in both groups at the beginning of the study. Patients randomized to Stroke Unit care had a Barthel Index score of 15/20 after 6 weeks of treatment and were on average discharged from hospital at 6 weeks. Patients randomized to the General Medical Unit had a Barthel Index score of 12/20 who were discharged at a mean of 20 weeks. The total amount of therapy provided was no
different between the stroke rehabilitation unit and the general medical unit. However, the SRU provided the same amount of therapy over a much shorter period of time; intensity of therapy was much higher on the SRU. This frontloading of therapy resulted in a dramatic improvement in outcomes and costs.

### 2.7.1 Intensity of Physiotherapy and Occupational Therapy

Animal studies have examined the number of repetitions in the affected upper extremity; animals in research reached 300 repetitions per session. The EXCITE trial, for instance involved 196 hours of therapy per patient. Kwakkel et al. (1997) included 8 RCTs and one non-randomized experiment and found a small but statistically significant effect of intensity on ADL and functional outcome parameters.

Kwakkel et al. (2004) (see Highlighted Study below) conducting an extension of his previous meta-analysis, evaluated the benefit of augmented physical therapy, including 20 studies which had assessed many interventions: occupational (upper extremity), physiotherapy (lower extremity), leisure therapy, home care and sensorimotor training. After adjusting for differences in treatment intensity contrasts, augmented therapy was associated with statistically significant treatment effects for the outcomes of ADL and walking speed, although not for upper extremity therapy assessed using the Action Research Arm test. A 16-hour increase in therapy time during the first six-months following stroke was associated with a favourable outcome.

#### HIGHLIGHTED STUDY


**Methods:** A systematic review to study the effects of augmented exercise therapy time (AETT) on various stroke outcomes was conducted of candidate articles published between 1966 and 2003. Using a fixed and random effects model, effect sizes were computed for ADL, walking speed and dexterity.

**Results:** 31 studies met the inclusion criteria, of which 20 were used for analysis, establishing a sample of 2686 stroke patients. At end of intervention, a small heterogeneous summary effect size was established for ADL (p<.05). A homogeneous summary effect size (p<.001) was established when therapy occurred within the first 6 months after stroke but not thereafter. A significant homogeneous summary effect size was also noted for walking speed (p=.017), but not for dexterity.

In summary, greater intensities of physiotherapy and occupational therapy appeared to result in improved functional outcomes.

### 2.7.2 Intensity of Aphasia Therapy Post Stroke

Bakheit et al. (2007) in a large RCT failed to uncover a benefit of intensive aphasia therapy as assessed using the Western Aphasia Battery. The average time from of stroke onset was one-month. The authors reported that the majority of patients receiving intensive treatment weren’t able to tolerate it. Patients were either too ill or refused therapy and actually had lower WAB scores compared with patients who received less intensive, standard therapy (68.6 vs. 71.4). While this study was considered to be negative, patients who received an average of 1.6 hours of therapy (standard group) per week had significantly higher scores than those who received only .57 hours of therapy (NHS group). Patients in the highest intensity therapy group received an average of 4 hours of therapy per week. Therefore, depending on how” intensive” is defined, this trial could be considered positive.
Bhogal et al. (2003) (see Highlighted Study below) observed that a significant treatment effect was achieved among studies which provided a mean of 8.8 hours of therapy per week for 11.2 weeks compared to trials that only provided approximately 2 hours per week for 22.9 weeks. On average, positive studies provided a total of 98.4 hours of therapy while negative studies provided a total of 43.6 hours of therapy. Consequently, total length of therapy was significantly inversely correlated with mean change in Porch Index of Communicative Abilities (PICA) scores. The hours of therapy provided in a week was significantly correlated to greater improvement on the PICA and on the Token Test. And finally, total hours of therapy were significantly correlated with greater improvement on the PICA and the Token Test. The authors concluded that intense therapy over a short amount of time could improve outcomes of speech and language therapy for stroke patients with aphasia (Bhogal et al. 2003).

**HIGHLIGHTED STUDY**

**Methods:** A systematic review to explore how the intensity of aphasia therapy (speech and language therapy) is associated with aphasia recovery in stroke patients. Intensity was determined by length (weeks), hours per week, and total hours of therapy. A database (MEDLINE) search for candidate articles that were published between 1975 and 2002 was conducted. Primary outcome measures were the PICA, FCP, and Token Test, and Pearson’s correlation coefficient was used to assess the relationship between intensity and outcome of therapy.

**Results:** 10 studies met the inclusion criteria which established a sample of 864 stroke patients. Hours of therapy per week (p=.001, p=.027), and total hours of therapy (p<.001) were both significantly correlated with improvement on the PICA and Token Test, whereas total length of therapy was found to be inversely correlated (p=.003) with change in PICA scores, suggesting that therapy lasting longer (in weeks) was less intense.

In summary, for patients who can tolerate it, more intensive therapy appears to result in improved outcomes.

### 2.7.3 Weekend Therapy

Sonoda et al. (2004) (see Highlighted Study below) conducted a trial in Japan comparing outcomes of stroke patients admitted to a conventional stroke rehabilitation program 5 days per week and patients admitted to a Full-time Integrated Treatment (FIT) program 7 days per week. Additional weekend therapy resulted in significant improvements in FIM efficiency as well as a reduction in length of stay.

**HIGHLIGHTED STUDY**

**Methods:** Historical comparison of 48 stroke patients treated admitted to a conventional stroke rehabilitation program in December 1999, compared to 58 patients treated by the Full-time Integrated Treatment (FIT) program. The key difference between the 2 programs was the intensity and frequency of treatment (80 minutes of OT/PT therapy 5x/week vs. same daily total of therapy time, but provided 7x/week, although patients were encouraged to remain active outside of structured sessions).

**Results:** Admission FIM scores between the 2 groups were similar (80.9, conventional vs. 81.2, FIT), however at discharge the FIT group had higher average FIM scores (97.1 vs. 105.0, p<0.01) and FIM efficiency, (change/LOS) (0.19 vs. 0.33, p<0.01). Hospital stays were also shorter for patients in the FIT group (72.9 vs. 81.1 days). The time from onset of stroke to admission into rehabilitation was 54 days for patients in the conventional group and 50 days for patients in the FIT group.
2.7.4 Inactive and Alone

Bernhardt et al. (2004) found that on a stroke unit during a therapeutic day stroke patients were shown to spend their time largely inactive. More than 50% of patients’ time was spent in bed, 28% was spent sitting out of bed and only 13% of time was spent in therapeutic activities. Patients were alone for 60% of the time which is contrary to the evidence that increased activity and environmental stimulation is important to neurological recovery. Lenze et al. (2004) noted that poor participation in therapy during inpatient rehabilitation was common, and was associated with less improvement in FIM scores and longer lengths of stay even when controlling for admission FIM scores.

2.7.5 Time Accountability: The Collaboration Evaluation of Rehabilitation in Stroke Across Europe (CERISE) Trial

<table>
<thead>
<tr>
<th>HIGHLIGHTED STUDY</th>
</tr>
</thead>
</table>

**Methods:** This study, the CERISE study, compared motor and functional recovery after stroke between 4 European Rehab Centers.

**Results:** Gross motor and functional recovery was better in Swiss and German than UK center with Belgian center in middle. Time sampling study showed avg. daily direct therapy time of 60 min in UK, 120 min in Belgian, 140 min in German and 166 min in Swiss centers. Differences in therapy time not attributed to differences in patient/staff ratio (similar staffing). No differences were found in the content of physiotherapy and occupational therapy. In German and Swiss centers, the rehabilitation programs were strictly timed (therapists had less freedom), while in UK and Belgian centers they were organized on an ad hoc basis (therapists had more freedom to decide). The authors reported “More formal management in the German center may have resulted in the most efficient use of human resources, which may have resulted in more therapy time for the patients”.

In summary, although the exact amount of therapy needed to optimize outcomes has yet to be determined, given the evidence, it seems prudent to provide therapies on a more intensive schedule. The beneficial effect may be greatest if high-intensity therapies are provided in the early stages of rehabilitation. One study has suggested that the addition of weekend treatment contributed to an almost doubling of FIM efficiency scores.

2.8 Task-Specific Treatment

2.8.1 Stroke Rehabilitation Must Be Task-Specific

Functional reorganization of cortex is greater for tasks meaningful to the animal; repetitive activity is not enough (Nudo et al. 2003). An element of skilled motor learning is required in addition to repetition for cortical reorganization/plasticity to occur. There is growing evidence that the cortex adjacent to the stroke-damaged region is important to recovery but only if stimulated and trained in the lost function (Hallett et al. 2001). The best way to relearn a given task, if the ability to perform it is lost following a
stroke, is to train specifically for that task. Rehabilitation must be task-specific, focusing on tasks important and meaningful to patient. Trends have been moving away from traditional Bobath and other NDT forms of treatment because they slow recovery and increase length of stay. Proponents of task-specific training cite that intense training is not always necessary for positive outcomes in stroke patients, but instead suggest that therapy designed to be more task-specific within normal contact time (30 to 45 minutes per session) could be more efficacious (Page 2003).

Several trials have evaluated task-specific therapies focusing on gait restoration.

- A pilot study by Richards et al. (1993) demonstrated that focused therapy on specific gait activities leads to positive outcome and not the amount of total therapy time.
- The results from the studies of both Dean et al. (2000) and Salbach et al. (2004) suggest that therapy designed to improve the strength and endurance of the affected lower limb and functional performance demonstrated improvement that was specific to the training.
- Monger et al. (2002) reported that six patients improved their sit-to-stand performance following a home-based, task-specific exercise program. Task-specific interventions associated with neglect have been especially promising.
- Enhanced visual scanning techniques improve visual neglect with subsequent improvement in function (Weinberg et al. 1977, 1979, Paolucci et al. 1996).

In summary, task-specific therapy allows for the best recovery. NDT or the Bobath restorative approach results in longer lengths of stay and offers no advantage over other therapy approaches. Task-specific therapeutic approaches allow for the best recovery with improved FIM scores, improved discharge destination and shorter lengths of stay.

### 2.8.2 Therapy Philosophies

**Compensatory Approach** is sometimes referred to as Task-Specific Therapy – concerns it may actually suppress neurological recovery.

**Restorative Approach** is often times referred to as Neurodevelopmental Techniques (NDT) and is best known as the Bobath approach (one form of NDT) after its strongest proponent.
Neurodevelopmental Training (NDT) Approaches

<table>
<thead>
<tr>
<th>Approach</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bobath</td>
<td>Aims to reduce spasticity and synergies by using inhibitory postures and movements in order to facilitate normal autonomic responses that are involved in voluntary movement (Bobath 1990).</td>
</tr>
<tr>
<td>Brunnstrom’s Movement Therapy</td>
<td>Emphasis on synergistic patterns of movement that develop during recovery from hemiplegia. Encourages the development of flexor and extensor synergies during early recovery, assuming that synergistic activation of the muscle will result in voluntary movement (Brunnstrom 1970).</td>
</tr>
<tr>
<td>Proprioceptive Neuromuscular Facilitation (PNF)</td>
<td>Emphasis on using the patient’s stronger movement patterns for strengthening the weaker motions. PNF techniques use manual stimulation and verbal instructions to induce desired movement patterns and enhance motor function (Myers 1995).</td>
</tr>
</tbody>
</table>

2.8.3 Bobath Approach/Neurodevelopmental Technique (NDT)

The Bobath approach is based upon a theoretical framework in a reflex-hierarchical theory. Synergistic movements are suppressed while normal movements are facilitated and encouraged. It is designed to maximize neurological recovery and limit impairment although there is not sufficient evidence that it actually improves impairment.

The goal of NDT is to normalize tone, to inhibit primitive patterns of movement, and to facilitate automatic, voluntary reactions and subsequent normal movement patterns. It is based on the concept that pathologic movement patterns (limb synergies and primitive reflexes) must not be used for training because continuous use of these pathologic pathways may make it too readily available at the expense of normal pathways. The goal is to suppress abnormal muscle patterns before normal patterns are introduced. Mass synergies are avoided, although they may strengthen weak, unresponsive muscles, because these reinforce abnormally increased tonic reflexes, spasticity.

There is strong evidence that NDT is not superior to other approaches. Based on the highlighted study below (Lanhammer and Stanghelle 2000) there is moderate evidence that Motor Relearning Program (task-specific training) results in short-term improvements in motor functioning and shorter lengths of hospital stay when compared to NDT.

HIGHLIGHTED STUDY

**Methods:** Double-blind trial 61 stroke patients randomized to receive Bobath or Motor Relearning Program.

**Results:** All patients received physiotherapy minimum of 40 mins x 5 days/wk while in hospital. Length of stay was 21 days in Motor Relearning Program vs. 34 days in Bobath (significant difference).

HIGHLIGHTED STUDY

**Methods:** 120 patients admitted to stroke rehab ward were randomized to Bobath based or movement science based rehab approach. Rivermead Motor Assessment (RMA) and Motor Assessment Scale (MAS) scores were assessed at 1, 3 and 6 months.

**Results:** No significant differences between the two groups. Scores on the subsections of both RAM and MAS associated with lower extremity function were similar.

HIGHLIGHTED STUDY

**Methods:** Controlled, multi-site cluster trial. 225 patients in 6 hospitals received rehabilitation on units using NDT approach and 101 patients on 6 wards received rehab on units using a conventional (non-NDT) approach.

**Results:** Primary outcome was a poor outcome (BI <12 or death) at one year. Quality of life also assessed. No differences in the proportion of patients experiencing a poor outcome. Adjusted odds ratio associated with NDT approach was 1.7. No differences in median Quality of Life at 12 months.

2.9 Outpatient Therapy

2.9.1 Importance of Outpatient Therapy

1. Outpatient therapy allows for earlier discharge of stroke rehabilitation patients into the community. Outpatient stroke rehabilitation is relatively inexpensive.
2. The resources devoted to fund one inpatient stroke rehabilitation bed could fund a full stroke rehabilitation outpatient team (full-time physiotherapist and occupational therapist and half-time speech-language pathologist and social worker) for one year.
3. Patients are often kept in expensive inpatient stroke rehabilitation beds longer than is necessary because of a lack of outpatient therapy.
4. Skills developed in stroke rehabilitation are reinforced and maintained in outpatient therapy.

HIGHLIGHTED STUDY

Based on the results from three RCTs, there is strong evidence that additional hospital-based outpatient therapy improves short-term functional outcomes when compared to routine care. However, the beneficial effects were not maintained in the long-term.

Based on the results from six RCTs, there is strong evidence that additional home-based therapy is not associated with improvement in overall functional outcome, as measured by the Barthel Index, when compared to routine care. However, consideration must be given to the low intensity of the interventions provided and the difficulty in detecting small, but clinically important changes in outcome when using the Barthel Index. Based on the results from 3 RCTs, there is conflicting evidence that home-based therapy for chronic stroke survivors is associated with improvements in mobility.

Based on the results from six RCTs, there is conflicting evidence of the superiority of home-based versus hospital-based outpatient stroke rehabilitation therapy. Positive outcomes were reported from study groups including both home-based and hospital-based therapy groups. There is limited evidence that hospital-based outpatient rehabilitation services are superior to home-based rehabilitation for frail elderly stroke patients. There is limited evidence that home-based rehabilitation is superior to hospital-based services for younger, severely involved stroke patients.

Outpatient therapy allows for maintenance of gains following stroke rehabilitation and improved community reintegration. Stroke rehabilitation outpatient therapy has been shown to improve outcomes and in particular help to maintain gains made in inpatient stroke rehabilitation. The benefits of outpatient therapy include the fact that the patient is more likely to remain at home through maintenance of gains and are more likely to be discharged home in a timely manner. An outpatient stroke rehabilitation program for severe strokes could significantly improve outcomes with many more patients able to return home and improve FIM scores over time. Outpatient therapy is an essential element of stroke care, yet it is often one of the first casualties of hospital cuts. In Canada, there are inadequate outpatient and community-based rehabilitation services for stroke patients. Unfortunately, this is a shortsighted strategy, which ultimately increases costly inpatient length of stay.

### 2.9.2 Early Supported Discharge (ESD)

In a hospital, stroke patients will typically receive acute care and a variable period of rehabilitation with rehabilitation services often reduced after discharge home from hospital (Langhorne 2003). ESD services aim to alter this conventional pathway of care in one of two ways: 1) Expediting earlier discharge from hospital; 2) Providing a more continuous process of rehabilitation spanning the transition period in hospital and at home (Langhorne, 2003). Many trials have been conducted to investigate on the effectiveness on ESD, with convincing evidence. The implementation of ESD has now been recommended in Canada, UK and Australia stroke guidelines.

ESD may be delivered in variations of delivery models. Three variations of delivery models have been identified in the Early Supported Discharge (ESD) Trialists Cochrane Review (2012). The efficacy of ESD for acute stroke patients was recently evaluated by the Early Supported Discharge Trialists, with the most
recent update in 2012 (Fearon & Langhorne 2012). The purpose of the review was to establish the effects and cost of ESD services compared to conventional services. The review included results from 14 trials on 1957 patients. The total results are presented in the table below:

### Statistical results on Outcome for ESD vs Conventional Care (Fearon and Langhorne 2012).

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Significant Result (Yes/No)</th>
<th>OR (95%CI) or Weighted Mean Difference (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Death</td>
<td>No</td>
<td>0.91 (0.67 to 1.25)</td>
</tr>
<tr>
<td>Death or need for institutionalization</td>
<td>Yes</td>
<td>0.78 (0.61 to 1.0)</td>
</tr>
<tr>
<td>Death or dependency</td>
<td>Yes</td>
<td>0.80 (0.67 to 0.97)</td>
</tr>
<tr>
<td>Length of initial hospital stay</td>
<td>Yes</td>
<td>-7.1 (-10.03 to -4.14)</td>
</tr>
<tr>
<td>Satisfaction with service</td>
<td>Yes</td>
<td>1.6 (1.08 to 2.38)</td>
</tr>
<tr>
<td>Extended ADL</td>
<td>Yes</td>
<td>0.12 (0.00 to 0.25)</td>
</tr>
<tr>
<td>Subjective health</td>
<td>No</td>
<td>0.0 (-0.10 to 0.11)</td>
</tr>
<tr>
<td>Number or readmissions to hospital</td>
<td>No</td>
<td>1.26 (0.94 to 1.67)</td>
</tr>
</tbody>
</table>

The review found there was a significant reduction in the number of patients requiring institutional care following discharge as well as reduced levels of dependency at 6 months. The ESD group also showed significant reductions (P < 0.0001) in the length of hospital stay equivalent to approximately seven days. Improvements were also seen in patients’ extended activities of daily living scores.

Patients who receive ESD services were more likely to report satisfaction with the services. There were no statistically significant differences seen in carers’ subjective health status, mood or satisfaction with services. The apparent benefits were no longer statistically significant at five-year follow-up.

The delivery models were classified according to the organisation of the multidisciplinary team (Fearon & Langhorne, 2012).

1. **Discharge coordination and delivery of home rehabilitation by ESD team**
   This delivery model comprised of a dedicated multidisciplinary team which coordinated discharge from hospital, post-discharge care and provided rehabilitation and patient care at home. The team would meet on a regular basis to plan patient care.

2. **ESD team coordination**
   A coordinated multidisciplinary team planned and supervised the hospital discharge and the immediate post-discharge care, but did not provide the home rehabilitation and support. This responsibility were passed on to the existing community-based agencies. The community based agencies did not usually provide coordinated multidisciplinary care.

3. **No discharge coordination by ESD team**
   Multidisciplinary care was available during the inpatient stay. The patient was discharged early to home but the multidisciplinary care ceased once patient was discharged. Subsequent care was provided by a range of community stroke services or by trained healthcare volunteers.

### Outcome on Death or Dependency for ESD vs Conventional Care Stratified by Level of Service Provision (Fearon and Langhorne 2012).

<table>
<thead>
<tr>
<th>Death or dependency</th>
<th>Significant results</th>
<th>Odds Ratio (OR) and 95% CI</th>
</tr>
</thead>
</table>
Overall result | Yes | 0.80 (0.64 to 0.97)  
ESD team with coordination and delivery | Yes | 0.71 (0.55 to 0.91)  
ESD team coordination | No | 0.77 (0.54 to 1.11)  
No ESD team coordination | No | 1.23 (0.79 to 1.91)  

In summary, the greatest benefits were seen in the trials evaluating a co-ordinated ESD team, which coordinated the hospital discharge, post-discharge care and delivery of home rehabilitation and support.

The usual key argument for ESD is that home provides an optimal rehabilitation environment, since the goal of rehabilitation is to establish skills which are appropriate to the home setting. Nevertheless, it is difficult to fully delineate the specific reasons for the success of ESD services as the reasons for success may be multi-factorial. Langhorn & Widen-Holmqvist (2007) noted it was not possible to specifically determine how ESD services improve patient outcomes as the different components of ESD services cannot be adequately separated within the trials used in the review. Nevertheless, the authors have listed the potential reasons for better results with ESD services, which are explained along the ESD pathway.

**ESD Advantages at Each Stage in Pathway**

<table>
<thead>
<tr>
<th>Stage in ESD Pathway</th>
<th>Potential Advantages of ESD</th>
</tr>
</thead>
<tbody>
<tr>
<td>In hospital</td>
<td>Avoiding some complication of hospital admission</td>
</tr>
<tr>
<td></td>
<td>Improving patient and carer morale</td>
</tr>
<tr>
<td></td>
<td>Focusing on more realistic rehabilitation goals</td>
</tr>
<tr>
<td>Discharge planning</td>
<td>Providing rehabilitation in a more relevant environment</td>
</tr>
<tr>
<td></td>
<td>Encouraging more focus on self-directed recovery</td>
</tr>
<tr>
<td></td>
<td>ESD services able to provide higher levels of therapy input over the whole patient journey</td>
</tr>
<tr>
<td>Home rehabilitation</td>
<td>More realistic understanding of future recovery</td>
</tr>
<tr>
<td></td>
<td>(Langhorne &amp; Widen-Holmqvist, 2007)</td>
</tr>
</tbody>
</table>

Early Supported Discharge Trialists (2012) have demonstrated that the greatest benefit is seen in mild to moderate stroke patients, specifically reduction in death or dependence. However, the greatest reduction in hospital length-of-stay were seen in the severe subgroup (Barthel score <10/20).

**Outcome for ESD based on Stroke Severity; Severe (Barthel <10) vs. Mild to Moderate (Barthel 10-20).**
### Outcome

<table>
<thead>
<tr>
<th></th>
<th>Initial Barthel &lt;10</th>
<th>Initial Barthel 10-20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Death or dependence</td>
<td>OR 1.40, 95% CI 0.83 to 2.36</td>
<td>OR 0.77, 95% CI 0.61 to 0.98</td>
</tr>
<tr>
<td>Length of stay</td>
<td>MD 28.32, 95% CI 17 to 40</td>
<td>MD 3.11, 95% CI 1 to 7</td>
</tr>
</tbody>
</table>

### HIGHLIGHTED STUDY


**Methods:** 114 of 1542 admitted stroke patients were randomized after discharge to receive either home intervention or usual post stroke care. Eligibility criteria included patients with persistent motor deficits post stroke with caregivers willing and able to provide live-in care over a 4-week period. At 28 days those stroke patients who still needed >1 assist to walk, or those with cognitive impairment or with disabling coexisting conditions were excluded. Barthel scores were approximately 84 on average.

**Results:** Duration of hospital stay reduced by 2.6 days (9.8 vs. 12.4) in the home treatment group. Barthel score did not change significantly between the two groups. Home therapy group did better on SF-36 physical health component and a community reintegration score vs. usual care. The total costs after 3 mos. associated with the home care group were significantly less compared to the usual care group ($7,784 vs. $11,065 Canadian, p<0.0001). Lower caregiver burden scores were associated with home intervention group.

### 2.9.3 Canadian Best Practice Guideline Update 2015

**Recommendations 4.1: Outpatient & Community-Based Rehabilitation**


i) Stroke survivors with ongoing rehabilitation goals **should continue to have access to specialized stroke services after leaving hospital** [Evidence Level A]. This should include in-home community-based rehabilitation services ... or facility-based outpatient services [Evidence Level A].

ii) Outpatient and/or community based rehabilitation services should be available and **provided by a specialized inter-professional team, when needed by patients, within 48 hours of discharge from an acute hospital or within 72 hours of discharge from inpatient rehabilitation** [Evidence Level C].

iii) Outpatient and/or community-based services **should be delivered in the most suitable setting based on patient functional rehabilitation needs, participation-related goals, availability of family/social support, patient and family preferences which may include in the home or other community settings** [Evidence Level C].

iv) Outpatient and/or community-based rehabilitation services **should include the same elements as coordinated rehabilitation services:**

- An interprofessional stroke rehabilitation team [Evidence Level A].
- A case coordination approach including regular team communication to discuss assessment of new clients, review client management, goals and plans for discharge or transition [Evidence Level B].
- **Therapy should be provided for a minimum of 45 minutes per day** [Evidence Level B] per discipline, 2 to 5 days per week, based on individual patient needs and goals [Evidence Level A] for at least 8 weeks [Evidence Level C].
References


Bernhardt J, Chitravas N, Meslo IL, Thrift AG, Indredavik B. Not all stroke units are the same: a comparison of physical activity patterns in Melbourne, Australia, and Trondheim, Norway. *Stroke 2008; 39:2059-2065.*


Katkrak PH, Black D, Peeva V. Do stroke patients with intracerebral hemorrhage have a better functional outcome than patients with cerebral infarction? *PMR 2009; 1(5):427-433.*


