2. Brain Reorganization, Recovery and Organized Care

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2.1 Important Principles of Rehabilitation

2.1.1 Neurological Recovery

- Neurological recovery is defined as recovery of neurological impairments and is often the result of brain recovery/reorganization; it has been increasingly recognized as being influenced by rehabilitation.
- The majority of neurological recovery occurs within the first 1-3 months.
- Afterwards recovery may occur much more slowly for up to one year.

Spontaneous or Intrinsic Neurological Recovery

- Neurological deficits resulting from a stroke are often referred to as 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.
- Most spontaneous recovery occurs during the first 3-6 months after the stroke.
- 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 has, until recently, been regarded as largely inaccessible to medical intervention or manipulation.

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 influenced by neurological recovery but is not dependent on it.

2.2 Mechanisms of Neurological Recovery

Neurological recovery is defined as recovery of neurological impairments and is often the result of brain recovery/reorganization.
2.2.1 Local Processes (Early Recovery)

Local processes leading to initial clinical improvement occur independent of behaviour or stimuli.

**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.

**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 diaschisis, particularly if the connected area of the brain is left intact. This is particularly true of non-cortical structures after cortical injury (Lo 1986).
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 \textit{reacquiring motor skills is associated with functional neurological reorganization occurring in the undamaged cortex} (Nudo 2003a).

\textbf{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).
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).
3. 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.
   - Ipsilateral cortical involvement is more prominent early on; however, persistence of ipsilateral cortical involvement is generally associated with larger strokes and a poorer recovery.

\textbf{2.3 Time Course of Recovery}

- \textit{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, Ferucci et al. 1993, Kelley-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.

\textbf{Predictors of Functional 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.

2.4 Predictors of Stroke Recovery

2.4.1 Stroke Severity as Predictor

• Best predictor of stroke outcome is initial clinical assessment of stroke severity.
• 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), as noted above, two-thirds of all stroke survivors have mild to moderate strokes and are able to achieve independence in ADL.

**Table. 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>
<tr>
<td>Mild/No (45-58)</td>
<td>41</td>
<td>78</td>
<td>97%</td>
<td>2.5</td>
<td>6.5</td>
</tr>
</tbody>
</table>
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.

**2.4.2 Impact of Age on Recovery/Rehabilitation**

- Recovery is more rapid and occurs to a greater extent in younger individuals with a stroke.
- 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 Anderson 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.

### 2.4.3 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 stroke has been associated with more severe neurological deficits and has generally been 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 stroke and found that those with 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.
2.5 Measures of Functional Outcome

2.5.1 Barthel Index

Table. Barthel Index

<table>
<thead>
<tr>
<th>Questions</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>What does it measure?</strong></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><strong>What is the scale?</strong></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>
<tr>
<td><strong>What are the key scores?</strong></td>
<td>The index yields a total score out of 100 with higher scores indicating greater degrees of functional independence (McDowell &amp; Newell 1996).</td>
</tr>
<tr>
<td><strong>What are its strengths?</strong></td>
<td>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.</td>
</tr>
<tr>
<td><strong>What are its limitations?</strong></td>
<td>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 &amp; Counsell 1998).</td>
</tr>
</tbody>
</table>

2.5.2 Functional Independence Measure

The FIM assesses physical and cognitive disability in terms of burden of care – that is, the FIM score is intended to measure the burden of caring.

Table. Functional Independence Measure

<table>
<thead>
<tr>
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<td>Physical and cognitive disability in term of burden of care – that is, the FIM score is intended to measure the burden of caring.</td>
</tr>
<tr>
<td><strong>What is the scale?</strong></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 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><strong>What are the key scores?</strong></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>
</tbody>
</table>
What are its strengths?
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.

What are its limitations?
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.

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)
- Dressing (lower body)
- Toileting

2.5.3 Modified Rankin Handicap Scale

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

Table. Modified Rankin Handicap Scale

<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 prestroke 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>
</tbody>
</table>
What are its strengths?
The Modified Rankin Scale is an extremely simple, time efficient measure. Feasible for use large centers or in large trials (Wade 1992; de Haan et al. 1995). The MRS requires no special tools or training.

What are its limitations?
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 any rehabilitation intervention.

<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

2.6 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

2.6.1 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

12 good to fair RCTs comparing general multidisciplinary rehab (general medicine, geriatric or neurology units) vs specialized interdisciplinary stroke rehab (dedicated units).

**STUDY**


29 trials (6536 patients)
- 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)

*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</td>
<td>No trials</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Life support facilities</td>
<td></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>
<tr>
<td>Mixed Neuro-rehabilitation</td>
<td>Variable</td>
<td>Weeks</td>
<td>Mixed patient group</td>
<td>Better than non-specific stroke rehab</td>
</tr>
</tbody>
</table>
The Impact of Stroke Unit Care on Combined Death/Dependency Post Stroke (Foley et al. 2007)

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
STUDY


- 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.
- 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.

STUDY


- Best predictor of stroke outcome is initial clinical assessment of stroke severity
- Stroke patients will be classified by severity and individual treatment programs set up
- Expectation of standardized assessment tools and demonstration of outcomes
- Acute stay 10 days – randomized to Rehab Unit or Community Care
- Rehab Unit LOS = 27.8 days
- Community Care - 40% nursing home, 30% outpatient therapy, 30% no formal rehab treatment
- 7 month follow-up for all stroke patients
- Dependent (BI < 75) or dead - 23% vs 38% (p=.01)
- 39% reduction in worse outcomes with stroke rehabilitation

Moderate to severe stroke (BI<50) (n=114):
- 62% CR vs. 32% RU dead or dependent (p=.002)
- 48% reduction
- Barthel Index scores - 90 vs. 73 (p=.005).

Moderate to severe stroke patients make the greatest improvement in stroke rehabilitation
Milder strokes can be rehabilitated in community/outpatient setting without negative functional outcomes.

STUDY


- 220 acute (within 7 days) stroke patients randomized to either a combined acute/rehabilitation stroke unit or a general medical unit.
- 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 still seen at 10 years.

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

**Elements of Stroke Rehabilitation**

**2.7 The Earlier the Better**

- Brain is “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.
- Clinical association between early admission to rehab and better outcomes.

**2.7.1 Benefit of Early Therapy in Animals**

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

**STUDY**
- Subjected rats to rehab x 5 weeks beginning at 5, 14 and 30 days post small strokes
- Control animals – social housing
- All received 5 weeks of enriched environment
- Day 5 admission marked improvement
- Day 14 moderate improvement
- Day 30 no improvement vs. controls
- Corresponding cortical reorganization in brain around stroke.
2.7.2 Clinical Evidence for Early Therapy

- In clinical studies earlier rehab is associated with better functional outcomes which reduces formal and informal care needs.

**STUDY**
- 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.
- 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.

**STUDY**
- 435 patients admitted to an inpatient stroke rehab program within 150 days of a first unilateral stroke.
- 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.
- LOS 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.
- The AVERT trial is the first RCT to explore the importance of early rehabilitation.

**STUDY**
The AVERT Trial (*A Very Early Rehabilitation Trial*) is a large multi-centre study on the importance of early timing in stroke rehabilitation is the AVERT Trial. The AVERT trial consists of 3 phases:
- Phase I: Gather data baseline on current practice (completed)
- Phase II: Trial Protocol tested for feasibility and safety (completed)
- Phase III: Test for efficacy and cost-effectiveness (multi-centre, ongoing)
Studies performed during Phase II of the trial demonstrated that very early rehabilitation was feasible and safe. In addition, patients who underwent earlier and more intensive mobilization after stroke may
achieve earlier return to unassisted walking and improve functional recovery compared to those receiving standard care. [Bernhardt et al. (2008), Sorbello et al. (2009), Cumming et al. (2011)]


- 71 patients within 24 hrs of stroke onset were randomly assigned to receive standard care (SC) (n=33) or SC plus very early mobilization (VEM) (n=38).
- In the VEM group the goal was first mobilization within 24 hours of stroke symptom onset. VEM continued daily for the first 14 days after stroke or until discharge (whichever was sooner) and was delivered by a nurse/physiotherapist. It was intended to provide twice the therapy compared with the SC group.
- The primary safety outcome was the number of deaths at 3 months. A good outcome, defined as a modified Rankin Score (mRS) of 0-2 at 3, 6 and 12 months was also assessed.
- Results showed that there was no significant difference in the number of deaths between groups (SC, 3 of 33; VEM, 8 of 38; p=0.20). Almost all deaths occurred in patients with severe stroke. After adjusting for age, baseline NIHSS score and premorbid mRS score, the odds of experiencing a good outcome were significantly higher at 12 months for the VEM group (OR: 8.15, 95% CI 1.61-41.2, p<0.01).
- There was also a trend towards good outcome at 3 months, but not at 6 months.


- This study was a secondary analysis from Phase II AVERT trial, examining the complications between the trial groups [very early mobilization (VEM) vs. standard care (SC)]. Complications were classified according to type, number and severity of complications.
- There were no significant group differences in the number, type or severity of complications by 3 months. Patients in the SC group experienced a total of 91 counts of complications while patients in the VEM group experienced 87.
- Most patients (81.6%) experienced one or more complications.
- The multivariate analysis showed older age (OR 1.10, 95% CI: 1.02–1.18, p = 0.009) and longer length of stay (OR 1.18, 95% CI: 1.06–1.32, p = 0.002) were associated with experiencing an immobility-related complication.

**Cumming TB, Thrift AG, Collier JM, Churilov L, Dewey HM, Donnan GA et al. Very early mobilization after stroke fast-tracks return to walking: further results from the phase II AVERT randomized controlled trial. Stroke 2011; 42(1):153-158.**

- Patients in the very early and intensive mobilization group returned to walking significantly sooner than did standard stroke unit care controls (P=0.032; median 3.5 vs. 7.0 days).
- There were no differences in proportions of patients who were independent on the BI (score of 20) or who had achieved a good outcome on the Rivermead Motor Assessment Scale (score of 10-13) at either 3 or 12 months.
- VEM group assignment was a significant, independent predictor of independence on the BI at 3 months, but not at 6 months.

The Phase III trial is currently ongoing in the UK, Australia, Canada, New Zealand and South East Asia.
Clinical Practice Guidelines (Duncan et al. 2005) “recommend that rehabilitation therapy start as early as possible, once medical stability is achieved”.

2.8 Intensity: More is Better

- Post-stroke rehab increases motor brain reorganization, while lack of rehab reduces reorganization.
- More intensive motor training in animals further increases brain reorganization.
- The greater the intensity of therapies clinically, the better the outcomes.
- Seen to be true for physiotherapy, occupational therapy, aphasia therapy, treadmill training and upper extremity function in selected patients (i.e. CIMT).

STUDY
- RCT of 146 “middle band” strokes to stroke unit (SU) or gen med (GM) unit.
- Median BI = 4/20 initially in both.
- Stroke Unit - BI = 15 after 6 weeks; discharged at 6 weeks.
- General Medical Unit - BI = 12 after 12 weeks; discharged at 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.

2.8.1 Intensity of Physiotherapy and Occupational Therapy

- 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 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.
STUDY

- A systematic review to study the effects of augmented exercise therapy time (AETT) on various stroke outcomes. Searched for candidate articles published between 1966 and 2003. Using a fixed and random effects model, effect sizes were computed for ADL, walking speed and dexterity.
- Thirty-one 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 result in improved functional outcomes.

2.8.2 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 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).
STUDY

- 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.
- Ten 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.

2.8.3 Weekend Therapy

- Sonoda et al. (2004) (See 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.

STUDY

- 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).
- 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.
2.8.4 Inactive and Alone

In a therapeutic day stroke patients were shown to spend their time:
- >50% in bed
- 28% sitting out of bed
- 13% in therapeutic activities
- Alone for 60% of the time

Contrary to the evidence that increased activity and environmental stimulation is important to neurological recovery.

**Therapy Participation**

- Lenze et al. (2004) noted that poor participation in therapy during inpatient rehab was common.
- Associated with less improvement in FIM scores and longer lengths of stay even when controlling for admission FIM scores.

2.8.5 Time Accountability: The CERISE Trial

**STUDY**


- Study compared motor and functional recovery after stroke between 4 European Rehab Centers.
- 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).

"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 of 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.
2.9 Task-Specific Treatment

2.9.1 Stroke Rehabilitation Must Be Task-Specific

- Functional reorganization of cortex greater for tasks meaningful to animal; repetitive activity 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 (Hallet 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. Rehab must be task-specific, focusing on tasks important and meaningful to patient.
- Trends 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.
2.9.2 Therapy Philosophies

<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>
2.9.3 Bobath Approach/Neurodevelopmental Technique

- Bobath approach is based upon a theoretical framework in a reflex-hierarchical theory.
- Synergistic movements are suppressed while normal movements are facilitated and encouraged.
- Designed to maximize neurological recovery and limit 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.
- 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.
- Abnormal patterns modified at proximal key points of control (e.g., shoulder and pelvic girdle).
- Strong evidence that NDT is not superior to other approaches.
- 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.

STUDY
- Double-blind trial 61 stroke patients randomized to receive Bobath or Motor Relearning Program.
- All patients received physiotherapy minimum of 40 mins x 5 days/wk while in hospital.
- LOS was 21 days in MRP vs. 34 days in Bobath (significant difference).

STUDY
- 120 patients admitted to stroke rehab ward 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.
- No significant differences between the two groups.
- Scores on the subsections of both RAM and MAS associated with lower extremity function were similar.

STUDY
- 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.
- 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.

Summary: NDT vs. Motor Learning Approach

- Strong evidence that Bobath approach is not superior to other therapy approaches
- Conflicting evidence that the Motor Learning Approach (see below) is superior to Bobath approach for achieving improvements in functional outcome
- Moderate evidence that a MLA reduces length of hospital stay

2.9.4 Motor Relearning Program (Carr and Kenney 1992, Carr et al. 1985)

- Based on cognitive motor relearning theory.
- Goal is for the patient to relearn how to move functionally and how to problem solve during attempts at new tasks.
- Instead of emphasizing repetitive performance of a specific movement for improving skill, it teaches general strategies for solving motor problems.
- Emphasizes functional training of specific tasks, such as standing and walking, and carryover of those tasks.

2.10 Outpatient Therapy

2.10.1 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.

STUDY

- 327 stroke patients were randomized to receive domiciliary service for up to 6 months or hospital-based rehabilitation services.
- Domiciliary group showed significantly greater performance on Extended ADL household and leisure sub-scores at 6 months.
- Relative risk of death or institutionalization in the domiciliary group was 1.6 after one year.
STUDY

- 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.

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.
2.10.2 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 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>
<tbody>
<tr>
<td>Overall result</td>
<td>Yes</td>
<td>0.80 (0.64 to 0.97)</td>
</tr>
<tr>
<td>ESD team with coordination and delivery</td>
<td>Yes</td>
<td>0.71 (0.55 to 0.91)</td>
</tr>
<tr>
<td>ESD team coordination</td>
<td>No</td>
<td>0.77 (0.54 to 1.11)</td>
</tr>
<tr>
<td>No ESD team coordination</td>
<td>No</td>
<td>1.23 (0.79 to 1.91)</td>
</tr>
</tbody>
</table>

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 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 results are presented in Table 2.

### 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 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. Langhorne & Widen-Holmquist (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.

### Stage in ESD Pathway | Potential Advantages of ESD
---|---
In hospital | Avoiding some complication of hospital admission
Discharge planning | Improving patient and carer morale
| Focusing on more realistic rehabilitation goals
Home rehabilitation | Providing rehabilitation in a more relevant environment
| Encouraging more focus on self-directed recovery
| ESD services able to provide higher levels of therapy input over the whole patient journey
Discharge from ESD service | More realistic understanding of future recovery

(Langhorne & Widen-Holmquist, 2007).

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).

<table>
<thead>
<tr>
<th>Outcome</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>

**STUDY**


- 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.
- 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.
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.*


Forster A, Young J. The clinical and cost effectiveness of physiotherapy in the management of elderly people following a stroke. *Bradford Elderly Care and Rehabilitation Research Department, UK, 2002.*


Katrak 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.*


