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The Rehabilitation of Severe Stroke

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Abstract

Severe strokes often result in multiple disabilities, they are the most disabled group of stroke patients and the greatest rehabilitation challenge. Individually, severe stroke patients incur the greatest costs to the healthcare system, primarily due to greater length of stay (LOS) in hospital and the frequent need for long-term care or institutionalization (Navarrete-Navarro et al. 2003). Research relating to the definition, classification, neuro-recovery and rehabilitation of severe strokes is provided in this review. Clinical evidence for various severe stroke rehabilitation models are discussed (including slow-stream, intensive care unit (ICU), and specialized interdisciplinary stroke rehabilitation). Ethical issues pertaining to severe stroke are also presented.

Key Points

Stroke Recovery and Severity

- Smaller or moderate sized strokes have a greater capacity for a complete or near complete recovery when compared to larger more severe strokes.

- Neuroimaging studies indicate that compensatory mechanisms in combination with cortical reorganization explain much of the functional and structural changes occurring after a severe stroke.

- Cortical connectivity and corticospinal integrity may be better predictors of recovery than lesion anatomy (i.e. size).

Care of Individuals with Severe Stroke

- Though it is rare for severe stroke patients to be admitted to an ICU, their outcomes suggest it may be beneficial in reducing mortality. More studies are needed to determine whether the ICUs are better acute units for severe stroke patients compared to general stroke wards.

- Greater stroke severity is associated with poorer rehabilitation outcomes when compared to less severe strokes.

Issues

- Patients with severe stroke often have less access to rehabilitation.

- Severe strokes can pose a significant challenge to the current healthcare and rehabilitation system.

- Although there is no single definition for severe stroke, a commonly used indicator is early (first 3-5 days post stroke) FIM® score <40.

- Rehabilitation funding models can have direct implications for the care of individuals with severe stroke.

Outcomes of Rehabilitation

- Severe stroke patients admitted to specialized interdisciplinary stroke rehabilitation units have better health outcomes (medical morbidity and mortality) compared to those admitted to general (rehabilitation) wards.

- Specialized interdisciplinary stroke rehabilitation units do not always result in better functional outcomes or reduced lengths of stay, although most studies show improvement in both functional outcomes and length of hospital stays.

- Rehabilitation of individuals with severe strokes should emphasize discharge planning and a reduction in stroke related complications.

Slow Stream Rehabilitation

- At present, there is insufficient evidence to suggest that slow –stream rehabilitation is an effective intervention when compared to more specialized interdisciplinary stroke rehabilitation units.

Ethical Issues

- Ethical decisions regarding care of severe stroke patients should be based on trial treatments, and collaboration between attending medical staff and the patient and/or the patient's family.

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22.1 Stroke Recovery and Severity

22.1.1 Cortical Reorganization Following Stroke

In animals, neurological and functional recovery after cortical injury is dependent upon reorganization of the remaining cortical circuitry, including increased dendritic arborisation and increased neuron spine density (Kolb et al. 2000). There is an abundance of evidence that brain reorganization takes place in the uninjured cortical tissue surrounding the damaged area of the brain. Nudo (2003) *(page 8)* suggested that the mechanisms which *"underlie functional modifications in the motor cortex of normal animals during motor skill learning … [are likely the] … same mechanisms [that] play a role in recovery after damage to the motor cortex"* and that this is particularly true for small focal lesions in the sensorimotor cortex. Further, when damage occurs to a portion of the cortex, as in stroke, much of the surrounding undamaged cortex will be impacted because of the loss of the intracortical projections both to and from the area of injury, a process sometimes referred to as diaschesis (Frost et al. 2003). Hence, during the period of recovery during rehabilitation, a process of brain reorganization can be anticipated in adjacent and remote areas of the cortex that are connected to the damaged region.

22.1.2 Role of Reciprocal Motor Area Connectivity in Reorganization

Frost et al. (2003) studied infarcts in the primary motor cortex hand representation area of monkeys and reported that the amount of expansion in the hand area of the ventral premotor cortex was directly proportional to the amount of damage to the primary motor cortex. It appeared as though secondary motor areas were being called on to compensate for the lost function. Greater cortical damage resulted in more widespread attempts to reorganize the remaining cortical areas. However, this strategy has inherent issues as more distant and less well connected cortical regions are recruited, which results in continued impairment of functions represented by the damaged area of the brain. Frost et al. (2003) *(page 3211)* suggested two principles to explain this event: "reorganization of secondary cortical areas is a general feature of injury-induced plasticity," and "remote reorganization is directly related to the reciprocal connectivity of the various motor areas." With respect to the latter statement, there needs to be some form of connection to the damaged motor areas for functional reorganization to occur. This would mean that for much larger strokes, with both primary and secondary motor areas affected, there would be a reduced capacity for neurological reorganization. By injuring not only the primary area responsible for the lost function but also adjacent areas which normally would be called on to take over the lost function, more severe strokes have less capacity for neurological reorganization and recovery. Hence, the greater the damage to reciprocal intra-cortical pathways, the greater the plasticity seen in secondary intact areas; however, these secondary areas are less efficient and may not be preserved in more severe strokes, resulting in the reduced potential for recovery (Teasell et al. 2005).

23.1.3 Spontaneous Motor Recovery and the Importance of Intact Corticospinal Tract

Neurological recovery of the upper extremity post stroke consists of two components: spontaneous neurological recovery and functional recovery. Spontaneous neurological recovery involves recovery of impairment. It has been noted that within 6 months post stroke, upper limb impairment resolves by **fixed proportion**, which is 70% of each patient's maximum possible improvement (Prabhakaran et al. 2008). The 70% rule suggests a fundamental biological mechanism that holds true for patients across all ages and countries with different rehab services (Byblow et al. 2015). Upper limb impairment after stroke resolved by 70% of the maximum possible, regardless of the initial impairment (most often measured using the Fugl-Meyer score), but only for those patients with intact corticospinal (motor) tract function. Irreversible

structural damage to the corticospinal tract prevents ascending command signals from reaching the spinal cord and severely limits recovery of the upper limb movement (Stinear et al. 2012; Stinear et al. 2007). Proportional resolution of upper extremity impairment is dependent on corticomotor tract integrity. Motor Evoked Potential (MEPs) early post stroke are associated with recovery outcomes (Stinear 2010).

22.1.4 Effect of Lesion Size on Recovery

Neuroplasticity in the damaged hemisphere, particularly those in areas with peri-infarct activity, are associated with the best recovery (Cramer et al. 2002; Hallett 2001). Research examining the impact of smaller strokes, in which the damaged area of the brain is partially preserved, where adjacent or connecting areas have remained intact, and the corticospinal tract is preserved, has demonstrated that both patients and animals display an almost full and timely recovery (Whishaw 2000). Although recovery following a small stroke is often complete, the overall benefit of rehabilitation for patients with a small stroke is much less than that for patients with more severe strokes due to a "ceiling" effect. Recovery after a small stroke is often spontaneous and involves intact areas that already serve the affected function; therefore, rehabilitation therapies are not deemed to be critical to recovery.

As one example, Whishaw (2000) found that rats with small motor cortical lesions resulting in severe impairment initially performed poorly on skilled forelimb reaching tasks but demonstrated significant improvements over a 15-day period. Eventually, these rats were able to perform reaching tasks almost normally and demonstrated only mild impairments in lifting, aiming, and advancing the limb. In contrast, rats with larger lesions had a less complete return of function over a protracted period of time, generally weeks or months (Kolb 1995). Kolb (1995) noted that the larger lesions resulted in chronic loss of certain forelimb movements; even though the animals learned to compensate by using manoeuvres that involved the whole-body, in the end they were less successful in grasping food. Similarly in both animal and clinical studies, compensatory changes extended for up to 6 months in cases of more severe stroke (Green 2003).

Brain activity following a stroke will never return to a "normal" state due to the damage sustained regardless of the severity of the injury. However, functional recovery is largely dependent on the severity of the stroke, which is dictated by the integrity of the networks affected, and the post-stroke functional anatomy (Ward 2011). Swayne et al. (2008) found that motor performance after 3 months strongly correlated with intracortical excitability and to a lesser extent, with cortical tract integrity. These findings indicate that although recovery may be explained to an extent by the anatomy of the damage, the patient's state of cortical activity/connectivity may better predict clinical change (Swayne et al. 2008). In an earlier study by Schiemanck et al. (2005), the authors demonstrate that lesion volume correlated significantly with motor impairments, activities of daily living, the patient's well-being and their health status, but not with cognitive functioning, as measured by the MMSE.

Conclusions Regarding Stroke Severity and Recovery

Animal studies, combined with human neuroimaging, demonstrate that recovery post-stroke is largely dependent on peri-lesional intact cortical areas which subsume a similar function and can take over the lost function. Larger strokes have reduced potential for this to occur.

Neuroimaging studies suggest that although increased bilateral activity may occur following a stroke, this does not necessarily translate into functional recovery. A combination of residual activity, compensatory actions by surrounding regions, and cortical reorganization may play a role in the activity observed.

Although anatomical integrity of the brain may explain part of the recovery, recent studies suggest that cortical connectivity may better predict clinical change in the first three months after a stroke. More studies are needed to investigate the cortical connectivity patterns in patients post-stroke.

Smaller or moderated sized strokes have a greater capacity of a complete or near complete recovery when compared to larger more severe strokes.

Neuroimaging studies indicate that compensatory mechanisms in combination with cortical reorganization explain much of the functional and structural changes occurring after a severe stroke.

Cortical connectivity and corticospinal integrity may be better predictors of recovery than lesion anatomy (i.e. size).

22.2 Issues in Severe Stroke Rehabilitation

Severe strokes often result in a combination of significant motor, sensory and cognitive deficits. Individuals who have experienced a severe stroke constitute the most disabled group of stroke patients and present significant rehabilitation challenges. Although individuals with severe stroke have the greatest deficits, they often have limited access to rehabilitation. These individuals may be considered "poor candidates" for inpatient stroke rehabilitation because of perceived limitations to their rehabilitation potential (Gladman & Sackley 1998), because they do not make functional gains comparable to those made by individuals in the "middle band" of stroke severity (Alexander 1994; Ancheta et al. 2000; Asberg & Nydevik 1991; Carey et al. 1988) and because there are concerns about the cost effectiveness of rehabilitating these individuals (Gladman & Sackley 1998).

It is estimated that approximately 20% of stroke patients will experience severe functional deficits where they may remain non-ambulatory and continue to require assistance with activities of daily living (ADLs), irrespective of rehabilitation efforts (Pfeffer & Reding 1998). Further, it has been demonstrated repeatedly that the most powerful predictors of both functional recovery and eventual discharge home are initial stroke severity and patient age; however, the effect of age is not nearly as significant as that of stroke severity (Alexander 1994; Stineman & Granger 1998).

There is some evidence suggesting that patients with severe stroke benefit from specialized inpatient rehabilitation. Although these patients may make limited functional gains in response to specialized interdisciplinary stroke rehabilitation and are much less likely to obtain a near complete functional recovery, they do tend to experience reduced mortality, reduced length of stay in hospital and a greater likelihood of discharge home (Jorgensen et al. 2000, 1995).

Conclusions Regarding the Issues in Severe Stroke Rehabilitation

Despite having the greatest number of impairments and the most severe disabilities, patients often have limited access to rehabilitation.

Limited access to rehabilitation may be a result of many factors but in particular concerns about reduced potential for functional gains comparable to those individuals with moderate sized strokes.

Rehabilitation of individuals with severe stroke is associated with a greater use of rehabilitation

resources.

Patients with severe stroke often have less access to rehabilitation.

Severe strokes can pose a significant challenge to the current healthcare and rehabilitation system.

22.2.1 Defining Severe Strokes

Globally, there are various scales used to assess and study stroke severity (see Table 22.2.1.1). Appelros et al. (2002) proposed that the amount of initial trauma or risk of mortality upon admission may serve as a measure of severity while other authors have classified severe stroke as functional outcome post-rehabilitation or level of morbidity post-discharge (Nolfe et al. 2003). Acute health measures used to study severe stroke include the Acute Physiology and Chronic Health Evaluation (APACHE) (Riachy et al. 2008) and the National Institutes of Health Stroke Scale (NIHSS). Disability is often measured using the Functional Independence Measure (FIM®), Barthel Index: ADL Scale (BI-ADL), or the Modified Rankin Scale (MRS). Each of these assessment tools can be used independently or in combination for stroke assessment.

Table 22.2.1.1 Differences in defining "Severe Stroke" in Literature

Severe Stroke Event
Early-NIHSS score ≥6 (Appelros et al. 2002)
NIHSS score >15 (Lindsell et al. 2005)
Early-NIHSS score ≥11 (Gur et al. 2012; Kimura et al. 2005)
Early-NIHSS score >10 (Jeng et al. 2008)
Admission NIHSS score ≥20 (Bill et al. 2013)
Mean APACHE II score 13 (Riachy et al. 2008)
Severe Disability
Orpington Prognostic Score (OPS) >5 (Kalra et al. 1993; Kalra & Eade 1995)
Total early FIM® score <40 (Alexander 1994)
BI score <50 (at admission to rehabilitation) (Ronning & Guldvog 1998)
Early motor-FIM® score <37 (Stineman & Granger 1998)
Early motor-FIM® score 13-44 (Sandstrom et al. 1998)
Admission FIM® <54 (Ancheta et al. 2000)
BI score ≤10 (Fagerberg et al. 2000)
BI score <55 (Navarrete-Navarro et al. 2003)
FIM® < 40 (at discharge from acute care) (Nolfe et al. 2003)
FIM® ≤53 (Yagura et al. 2005)
BI score ≤ 40 9 (Holloway, 2005)
MRS score 4-5 (Holloway, 2005)
Glasgow Outcome Scale (GOS) score 2-3 (Holloway, 2005)
Motor-FIM® score ≤46 (Brock et al. 2007)
MRS score >2 (Jeng et al. 2008)
BI score <80 (Jeng et al. 2008)

Garraway et al. (1981) first proposed the concept of three bands of stroke severity (see Table 22.2.1.2). Individuals who were unconscious at onset and experiencing severe unilateral or bilateral paresis were described as having experienced a severe stroke. These patients may have also had serious medical comorbidities, which would have contributed to the severity of disability. Alexander (1994) and Nolfe et al. (2003) classify severe stroke as an early FIM® score <40. Individuals fulfilling this criterion were

considered unlikely to achieve functional independence regardless of treatment, with the exception of the younger (<55 years) population (Nolfe et al. 2003).

Table 22.2.1.2 Defining and Prognosticating Rehabilitation Potential Based on Stroke Severity (M. Garraway 1985; W. M. Garraway et al. 1981)

Upper Band	Middle Band	Lower Band
Minimal deficits Early (5-7 days) FIM®>80 or motor FIM®>62 Excellent recovery regardless of rehabilitation	Moderate deficits Conscious with significant hemiparesis Early FIM® 40-80 or motor FIM® 38-62 Marked improvements in rehabilitation and 85% discharged to community	Severe deficits Unconscious at onset with severe paresis or serious medical comorbidity Early FIM® score <40 or motor FIM® <37 Slower improvement, unlikely to achieve functional independence (unless young) and smallest likelihood of community discharge
[1]Garraway et al. (1981, 1985) actually defined more severe strokes as the upper band and milder strokes as the lower band; however, we have changed that around to avoid confusion since over the years actual classification has changed to be more intuitive.		

Finally, individuals with severe stroke have also been described as those who are non-ambulatory and at high risk for failure to return home due to physical, cognitive, perceptual, and communication difficulties, but generally due to a combination of the above (Evans 1981). See also chapter 4: Managing the Stroke Rehabilitation Triage Process (Levels of Stroke Severity).

Conclusions Regarding the Definition of Severe Stroke

Stroke severity has been defined in a variety of ways. Common definitions are unconsciousness with severe unilateral or bilateral paresis at onset; early FIM® score <40 or motor FIM® score <37; high risk for failure to return home due to physical, cognitive, perceptual, and communication difficulties, or a combination of the above.

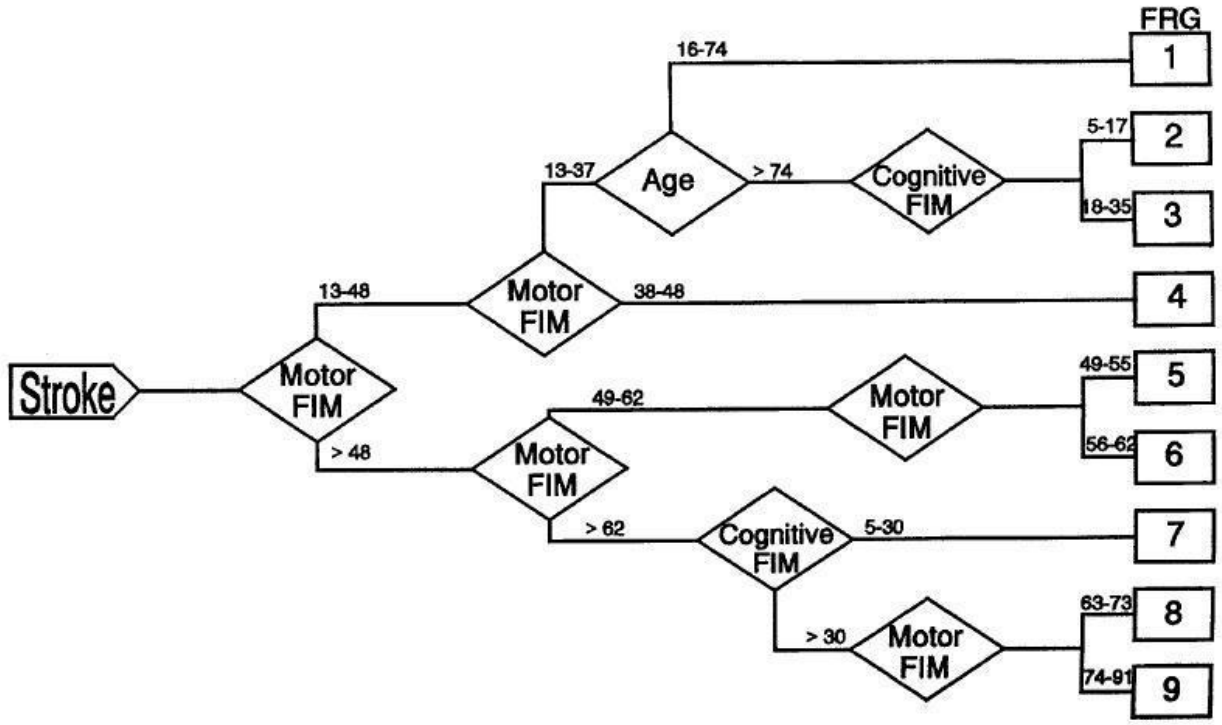
Although there is no single definition for severe stroke, a commonly used indicator is early FIM® (first 3-5 days post stroke) score <40.

22.2.2 Impact of Funding Models on Severe Stroke Rehabilitation

Evidence has shown that individuals with severe stroke represent a greater burden in terms of health and economic resources than individuals with mild and moderate strokes (Brock et al. 2007; Gladman & Sackley 1998; Stineman 1997). That being said, stroke severity can also have an impact on resources within the stroke rehabilitation unit. With the use of case-mix funding models, admission processes could bias towards certain stroke sub-groups (Ilett et al. 2010). There are concerns that a higher volume of severe stroke admissions could result in unfavorable reported outcomes, such as mortality (Ali et al. 2013). Bases toward selecting patients with less severe and "easier" strokes for rehabilitation, as those with more severe disabilities are more challenging and could adversely affect the `bottom line'. *"[Certain] funding models also have the potential to affect access to rehabilitation by providing financial incentives for admitting patients who are more likely to be profitable, rather than those who may receive significant benefits from the rehabilitation process" (page 827)* (Brock et al. 2007). Severe stroke patients typically have longer LOS, poorer functional outcomes, discharge challenges, and a need for more nursing care which may place them at a significant disadvantage when they are being considered as rehabilitation candidates.

For rehabilitation hospitals in North America, a common funding model used is the FIM® Function-Related Groupings (FIM®-FRG). FIM®-FRGs is a type of case-mix funding model that uses a decision tree to distinguish one class of patients from another (Figure 23.2.2.1) (Tesio 2003). Principle impairment, severity of disability, and age are all factors included in the FIM®-FRG classification of stroke patients (Stineman 1997). This model is widely used in the United States and often as part of a larger case-mix system encompassing a variety of healthcare centers (Stineman 1997; Stineman et al. 1997); it has been adopted in a number of jurisdictions around the world using different but similar measures, including our own province of Ontario in Canada. Stroke patients with the best measured gains post-rehabilitation are those of a young age with severe impairment(s) (FRG 1) (Bates & Stineman 2000). Midrange FRGs (4-7) typically experience significant positive functional gains, while older severe patients (FRG 2, 3) (with less recovery potential) and those with mild impairment (FRG 8-9) (recovery limited by a ceiling effect) often see less measured functional improvement at discharge (Bates & Stineman 2000; Han et al. 2002). Han et al. (2002) reported that stroke patients with multiple impairments often achieve less functional gains when compared to stroke patients with a single-impairment.

Figure 22.2.2.1 FIM®-FRG Grouping Structure (Stineman et al. 1997)



Research examining the introduction of similar systems has shown mixed benefits. For severe stroke patients, Brock et al. (2007) reported a FIM® grouping system reduced costs but increased level of disability at discharge; in other words patients were discharged sooner from rehabilitation. Dejong et al. (2005) found implementation of a FIM® classification system resulted in therapy resources being transferred from more severe stroke patients to those with moderate strokes. Further, Stineman (1997) echoes those results and states that both elderly and severe patients (classified using FIM®-FRGs) require additional considerations in a case-mix funding system.

Conclusions Regarding Funding Models and Severe Strokes

Severe strokes may be the most negatively affected by the type of funding models employed.

Rehabilitation funding models can have direct implications for the care of individuals with severe stroke.

22.3 Care of Individuals with Severe Stroke

Individuals with severe stroke experience the greatest number of impairments and limitations and are therefore at the greatest risk for expensive, long-term institutionalization (Gladman & Sackley 1998). However, despite this risk, severe stroke patients are often denied formal access to inpatient rehabilitation. See also chapter 4: Managing the Stroke Rehabilitation Triage Process.

22.3.1 Admission to Intensive Care Units

Evidence shows that severe stroke patients can benefit from admission to an ICU or a neuro-intensive care unit (NICU) (Jeng et al. 2008; Nguyen & Koroshetz 2003). However, very few severe strokes (5-7%) are admitted to ICUs (Navarrete-Navarro et al. 2003; Riachy et al. 2008). Riachy et al. (2008) demonstrated that, compared with other types of patients, ICUs admission rates have been reported lower or non-existent for stroke.

Jeng et al. (2008) found a reduced 1-year mortality rate in severe stroke patients treated in an ICU. However, the authors note that more research is required in order to establish the definitive benefits of intensive care for persons with severe stroke. The benefit of ICU care has been reported to be greatest for patients requiring continuous monitoring (Nguyen & Koroshetz 2003). In one RCT, admission to a stroke care monitoring unit (SCMU) which provided intensive monitoring of physiological parameters during the first 48 hours post-stroke in addition to conventional care, was found to be associated with a lower mortality rate compared to those admitted to conventional stroke units (Sulter et al. 2003). Other individuals with mechanical ventilation, post-stroke decompressive surgery, augmentation of cerebral perfusion, induced hypothermia, those at risk for brain hemorrhage because of post-thrombolysis, candidates for endovascular angioplasty, stenting, clot retrieval, or those with severe neurological impairment may also benefit from admission to intensive care (Jeng et al. 2008; Nguyen & Koroshetz 2003).

Currently, it is uncertain whether the type of stroke plays a role in the benefits obtained from recovering in the ICU. One study suggests that patients suffering from severe hemorrhagic strokes showed significantly greater improvements on walking ability and general disability after admission to the ICU, compared to those with ischemic strokes (Hu et al. 2010). Conversely, another study found that ischaemic stroke patients showed greater improvements on the physical component of the SF-36 compared to those with hemorrhagic strokes when admitted to an acute stroke care unit. It is important to note however, that the latter study included a cohort comprising mostly of patients with mild strokes which may have influenced the functional outcomes (Sulter et al. 2003).

Given that intensive care can play a critical role in the reduction of early stroke mortality and improved short-term and long-term outcomes, the tendency not to admit severe stroke patients is somewhat disconcerting. This may be a combination of the significant resource expenditure associated with ICU care and a prevailing nihilistic attitude towards treatment of severe strokes. On the other hand, this trend may also be location-specific, as one prospective study conducted in Taiwan indicated that the majority of the stroke patients admitted to the ICU had severe disabilities (NIHSS>10) (Hu et al. 2010). Roughly 45% of the stroke patients admitted to the ICU suffered from severe strokes, while 44% had moderate strokes

and the remaining 11% suffered from mild strokes (Hu et al. 2010). Although the data is encouraging, it is pertinent to note that the study included only 154 participants, and that the data was obtained from a single site. These limitations prevent the generalizability of the results across the whole population. More studies are encouraged to discern whether this pattern of stroke patient admission is location-specific.

Oftentimes, patients with severe disabilities are admitted to general stroke/rehabilitation units rather than ICUs. Even in conventional units, benefits have been observed. A prospective study conducted in Australia demonstrates that patients suffering from severe strokes improved significantly in motor function upon discharge from an inpatient rehabilitation unit (Hayward et al. 2014) Roughly 85% of patients with severe disabilities on admission improved to a moderate status (51.4%) or to a mild status (32.9%) regarding motor function on discharge (Hayward et al. 2014).

Conclusions Regarding Severe Stroke Admission to ICUs

Severe strokes are seldom admitted to intensive care units as compared with other types of critically ill or injured patients.

Severe stroke patients with critical health issues appear to have lower mortality rates when admitted to intensive care. Further research is needed to establish other specific outcome gains.

It is currently unclear whether stroke type influences the extent of the benefits that the ICUs may offer.

Though it is rare for severe stroke patients to be admitted to an ICU, their outcomes suggest it may be beneficial in reducing mortality. More studies are needed to discern whether the ICUs are better acute units for severe stroke patients compared to general stroke wards.

22.3.2 Stroke Severity and Rehabilitation Outcomes

There is clinical evidence that patients with severe stroke demonstrate poorer outcomes in a variety of domains relative to those with less severe stroke (Jeng et al. 2008; Kammersgaard et al. 2004; McKenna et al. 2002; Oczkowski & Barreca 1993; Ween et al. 1996; Ween et al. 2000). Severe strokes are associated with negative outcomes such as longer LOS, higher rates of mortality, dependence, or institutionalization, and lower functional ability.

In addition to having a higher mortality rate, patients with severe stroke are more likely to experience a longer LOS (in comparison with age-related peers+), and to remain severely disabled when compared to those with less severe stroke (de Villiers et al. 2011; Hayward et al. 2014; Kammersgaard et al. 2004; McKenna et al. 2002; Oczkowski & Barreca 1993; Ween et al. 1996; Ween et al. 2000). They are also less likely to show functional improvements during rehabilitation (Jeng et al. 2008; Maulden et al. 2005) Patients with cognitive impairments are found to have more severe strokes, compared to those without cognitive impairments (Rabadi et al. 2008).

Independent functioning at discharge was found to be predicted by admission NIHSS scores, suggesting that those with higher admission scores were more likely to be more independent upon discharge (Hu et al. 2010). Furthermore, independence at discharge correlated significantly with age and motor functioning (Hu et al. 2010). Patients with severe strokes that reported the greatest improvements were younger than those demonstrating poorer improvements at discharge (Kashihara et al. 2011). As expected, patients that received more intense rehabilitation also showed better motor function at discharge compared to those that received less intense rehabilitation (Hu et al. 2010).

Conclusions regarding Stroke Severity and Rehabilitation Outcomes.

More severe strokes, as determined upon admission, are associated with poorer outcomes after rehabilitation when compared with less severe strokes.

Greater stroke severity is associated with poorer rehabilitation outcomes when compared to less severe strokes.

22.4 The Outcomes of Rehabilitation of Severe Stroke

There is a growing body of evidence suggesting that patients with severe stroke benefit substantially from rehabilitation. Several authors have reported that, in response to specialized rehabilitation, these patients experience reduced mortality, increased likelihood of discharge home, and a shorter length of stay in hospital when compared to those treated in other settings (Jorgensen et al. 2000, 1995; Kalra & Eade 1995; Ronning & Guldvog 1998; Stineman & Granger 1998; Teasell et al. 2005; Yagura et al. 2005).

The results of studies examining severe stroke rehabilitation are described in Table 22.4.1.

Table 22.4.1 Summary of Studies Evaluating Stroke Rehabilitation Units

Author, Year PEDro Score Sample Size	Methods	Results
Fagerberg et al. (2000) RCT (8) N=249,75 severe (BI 0-15) patients	E: stroke unit C: conventional care	• Combined death and • dependency (-)
Claesson et al.(2003) Claesson et al.(2000) RCT (6) N=249	E: stroke unit C: general ward	• Discharge destination (-) • Readmission (-) • LOS (-)
Ronning & Guldvog (1998) RCT (6) N=251; 115 severe or moderate (BI<50) patients	E: stroke rehabilitation unit C: ad hoc care at home	• Combined Death and dependence (at 7 months) (+) • Barthel Index Scores (+)
Kalra et al. (1993) RCT (5) N=36	E: stroke unit C: general medical unit	• Barthel Index Scores (-) • Length of Stay (+) • Mortality (+) • Discharge home (-)
Kalra & Eade (1995) RCT (5) N=76	E: stroke unit C: general medical unit	• Barthel Index Scores (-) • LOS (+) • Mortality (+) • Discharge home (+)
Jorgensen et al. (2000; 1995) PCT N=1241	E: stroke unit C: general neurological unit	• Initial and 1 year mortality (+) • Poor Outcome (Death or LTC) (+) • LOS (-)
Yagura et al. (2005) PCT N=178, 27 severe patients	E: stroke rehabilitation unit C: general rehabilitation ward	• Discharge home (+) • FIM® scores (-) • Cost of rehabilitation (-)

Deutsch et al. (2006) Retrospective N=26,721 severe stroke	E1: inpatient rehabilitation facility (IRF) E2: skilled nursing facility (SNF)	• Discharge to community (for severe strokes aged <82 years) (+) • Motor FIM® gains (+) • LOS (+)
Di Carlo et al. (2011) Prospective N=355	E: Stroke unit C: geriatric wards	• Medical resource use (+) • LOS (-) • Discharge destination (home and rehabilitation hospitals) (+) • Mortality (at 3mo and at 1yr) (+) • Death or dependency (at 3mo and at 1yr) (+)

+ Indicates statistical significant difference between treatment groups
- Indicates non-statistically significant difference between treatment groups

Various researchers investigating a number of different outcomes have highlighted the benefits of specialized stroke rehabilitation for individuals with severe stroke. The most consistent benefits of specialized interdisciplinary rehabilitation for severe stroke patients are a reduced mortality rate (Jorgensen et al. 1995; Ronning & Guldvog 1998) and an increased likelihood of discharge home (McKenna et al. 2002; Ween et al. 1996).

Mortality
Jorgensen et al. (2000) reported that persons with the most severe strokes appeared to benefit the most initially, from rehabilitation in a dedicated stroke rehabilitation unit in terms of mortality when compared to other stroke patients. A similar finding was also reported by Ronning and Guldvog (1998), who demonstrated that patients with moderate and severe impairments received the most benefit from inpatient rehabilitation in terms of combined death and dependency.

Return Home
Yagura et al. (2005) reported that 47.4% of individuals with severe stroke admitted to an inpatient stroke unit were able to return home; in contrast, none of those admitted to a general rehabilitation ward were discharged home (Yagura et al. 2005). This number is similar to the 43% of severe stroke patients who were able to return home after undergoing a specialised stroke rehabilitation program (Teasell et al. 2005). Deutsch et al. (2006) conducted a retrospective review of stroke patients admitted to 631 Inpatient Rehabilitation Facilities (IRFs) and 239 Skilled Nursing Facilities (SNFs) across the United States. It was found that individuals with severe stroke admitted to IRFs were significantly more likely to be discharged to the community than those admitted to SNFs (Deutsch et al. 2006).

Length of Hospital Stay
Shorter lengths of hospital stay were reported for persons with severe stroke admitted to stroke rehabilitation units in 2 RCTs (Kalra et al. 1993; Kalra & Eade 1995). Median LOS of severe stroke patients in IRFs was shorter than those undergoing rehabilitation in SNFs (Deutsch et al. 2006). Finally, Jorgensen et al. (2000) and Yagura et al. (2005) concluded that there was no significant difference in LOS for patients with severe strokes admitted to rehabilitation units when compared to general medical wards.

Functional Gains
The benefits of rehabilitation for severe stroke patients, in terms of functional gains, have been less clear. Nolfe et al. (2003) found a significant improvement in median FIM® scores among severe stroke patients admitted to inpatient rehabilitation during the 6 month follow up; this trend has been observed in additional studies (Deutsch et al. 2006; Teasell et al. 2005). Ronning and Guldvog (1998) reported that moderate and severe stroke patients benefitted the most in terms of dependency. However, other

authors have reported no significant functional gains (as measured by the Barthel Index) in the severe stroke study population (Kalra et al. 1993; Kalra & Eade 1995).

Other Outcomes

It was reported that severe stroke patients admitted to a specialized geriatric stroke unit had improved psychological wellness at a 6 month follow-up (Lofgren et al. 1999). Finally, specialized care appears to be beneficial for patients with severe stroke who suffer from concomitant cardiac disease (Fagerberg et al. 2000).

Systematic Review

Pereira et al. (2012) conducted a systematic review of 14 studies (including 4 RCTs) that looked at outcomes of severe stroke admitted to various inpatient rehabilitation programs. Although persons with severe strokes make slower and fewer functional gains during inpatient rehabilitation, there is evidence to support significant benefits for this population in terms of decreased mortality, reduced LOS and increased likelihood of discharge to the community. The authors believe that this is sufficient to justify admission of persons with severe stroke to specialized inpatient rehabilitation facilities.

Conclusions Regarding the Benefits of Rehabilitation for Severe Strokes

There is level 1a evidence that specialized interdisciplinary stroke rehabilitation reduces mortality in severe stroke patients when compared to general rehabilitation programs.

There is level 1b and limited level 2 evidence suggesting that severe stroke patients who are admitted to specialized interdisciplinary stroke rehabilitation programs are more likely to be discharged home.

There is conflicting level 1a and level 2 evidence regarding the effect of specialized interdisciplinary stroke rehabilitation programs on hospital length of stay.

There is conflicting level 4 evidence regarding functional gains of persons with severe stroke following specialised interdisciplinary inpatient stroke rehabilitation.

Functional outcomes suggest that rehabilitation of severe stroke patients should emphasize discharge planning and reduction of post-stroke complications.

Severe stroke patients admitted to specialized interdisciplinary stroke rehabilitation units have better health outcomes (medical morbidity and mortality) compared to those admitted to general (rehabilitation) wards.

Specialized interdisciplinary stroke rehabilitation units do not always result in better functional outcomes or reduced length of stay, although most studies show improvement in both functional outcomes and length of hospital stays.

Rehabilitation of individuals with severe strokes should emphasize discharge planning and a reduction in complications.

22.5 Slow Stream Rehabilitation

Slow-stream rehabilitation has been suggested as an alternative for individuals with a severe stroke who may not be able to tolerate intensive therapy but could benefit from low intensity rehabilitation (Tourangeau et al. 2011). It aims to provide specialized stroke rehabilitation services over longer periods of time to individuals with more severe deficits who may not traditionally be considered good candidates for inpatient rehabilitation (O'Neill et al. 1987). O'Neill et al. (1987) studied 52 individuals with mixed diagnoses admitted to a slow-stream rehabilitation unit and reported that this form of rehabilitation could result in both social and economic benefits. However, Richmond et al. (1988) raised some interesting questions about these conclusions. Although 36% (n=19/52) returned home following slow-stream rehabilitation, only 9 remained home 6 to 30 months later. Moreover, they attempted to compare costs of slow-stream rehabilitation to nursing home care and suggested that the former may be the more expensive of the two. In Canada, the majority of costs associated with the delivery of inpatient stroke rehabilitation are associated with nursing and accommodation rather than the provision of core therapies (physiotherapy, occupational therapy and speech language pathology). In fact, less than 25% of costs are attributable to core therapies. Therefore, it is important to ensure that patients receive as much of the core therapies as is tolerable to them within a short period of time. All of the research that demonstrated significant improvements over conventional care in the rehabilitation of patients with severe stroke involved interdisciplinary, relatively therapy intensive stroke rehabilitation units, and not less intensive versions. Hence, the intensity of therapy received should be dictated by the tolerance of the individual patient and not by preconceived notions about the amount of therapy that severe stroke patients can successfully tolerate (Teasell et al. 2005).

At present, the concept of slow-stream stroke rehabilitation for individuals with severe stroke remains relatively untested. Torangeau et al. (2011) described the outcomes of 81 individuals admitted to "low intensity, long duration" units across 6 facilities in Ontario. They reported that 48% of these individuals (who would have not been considered as candidates for traditional intensive rehabilitation) were able to return home, 35% were discharged to settings that needed lower levels of care (e.g nursing homes) and 17% were discharged to more costly settings where higher levels of care were provided (Tourangeau et al. 2011).

In the United States, a large comparative study examined stroke rehabilitation outcomes at 3 and 6 months with regard to long-term placement, functional status and cost (Kramer et al. 1997). This study included case mix-adjusted populations treated in rehabilitation hospitals, specialized rehabilitation nursing homes and traditional nursing homes. Findings indicated that patients in the rehabilitation hospital experienced significantly greater functional recovery when compared to those who received specialized rehabilitation in the nursing home or those treated in a traditional nursing home. Medicare costs associated with services provided in the rehabilitation hospital setting were 1.5 times greater than those in sub-acute rehabilitation and twice that of traditional nursing home rehabilitation. The odds of returning to the community doubled for rehabilitation hospital patients in comparison to the other two groups. Additionally, rehabilitation patients who received specialized nursing home rehabilitation were more likely than those in a traditional nursing home to be discharged to the community, though this trend did not reach significance (Kramer et al. 1997). This study demonstrated that the more intensive and specialized the stroke rehabilitation, the more likely the stroke patient was to be discharged home (Teasell et al. 2005). See also chapter 4 (Managing the Stroke Rehabilitation Triage Process).

Conclusions Regarding Slow-Stream Rehabilitation

Some data suggest that slow-stream stroke rehabilitation may result in less favourable outcomes when compared to the more intensive stroke rehabilitation program.

The utilization of slow stream rehabilitation should be dictated by the tolerance of the individual patient for therapy and not by preconceived notions about the amount of therapy that patients can successfully tolerate.

At present, there is insufficient evidence to suggest that that slow-stream stroke rehabilitation is an effective intervention when compared to more specialized interdisciplinary stroke rehabilitation units.

22.6 The Ethical Issues in Severe Stroke Rehabilitation

The severe stroke patient is likely to have a worse prognosis and require more resources than a moderate or mild stroke patient (Gladman & Sackley 1998). This being said, recovery from a severe stroke can be quite significant when one is willing to invest the resources.

An ethical concern in rehabilitation is the decision as to whether a severe stroke patient who has survived the acute phase should be admitted to a specialized interdisciplinary stroke rehabilitation unit, especially in the face of limited resources. In other words, stroke rehabilitation specialists are often called upon to decide between a moderately severe stroke and a more severe stroke patient. With limited resources it is important to ensure that persons most likely to benefit receive rehabilitation. Kennedy et al. (2012) examined the key factors, from a physician's perspective, involved in the decision making process regarding the admission of persons with severe stroke to rehabilitation. The authors noted that the key patient factors considered included prognosis, social factors, anticipated discharge destination, and age. Some sites also considered anticipated length of stay. The authors indicated that variability in selection practices is common and extensive investigation into various factors influencing outcome is needed to optimize the use of resources.

Conclusions Regarding Severe Stroke Rehabilitation Ethics

More research needs to be conducted in the area of severe stroke prognosis.

Trial treatments may assist in creating a more accurate basis for ethical decision-making.

Ethical decisions regarding care of severe stroke patients should be based on trial treatments, and collaboration between attending medical staff and the patient's family.

Summary

1. ***Animal studies, combined with human neuroimaging, demonstrate that recovery post-stroke is largely dependent on peri-lesional intact cortical areas which subsume a similar function and can take over the lost function. Larger strokes have reduced potential for this to occur.***

2. ***Neuroimaging studies suggest that although increased bilateral activity may occur following a stroke, this does not necessarily translate into functional recovery. A combination of residual activity, compensatory actions by surrounding regions, and cortical reorganization may play a role in the activity observed.***

3. ***Although anatomical integrity of the brain may explain part of the recovery, recent studies suggest that cortical connectivity may better predict clinical change in the first three months after a stroke. More studies are needed to investigate the cortical connectivity patterns in patients post-stroke.***

4. ***Severe strokes are seldom admitted to intensive care units as compared with other types of critically ill or injured patients.***

5. ***Severe stroke patients with critical health issues appear to have lower mortality rates when admitted to intensive care. Further research is needed to establish other specific outcome gains.***

6. ***Despite having the greatest number of impairments and the most severe disabilities, these patients may have limited access to rehabilitation.***

7. ***Limited access to rehabilitation could be a result of many factors such as their reduced potential for functional gains comparable to those individuals with moderately-severe stroke.***

8. ***Rehabilitation of individuals with severe stroke is associated with greater use of resources.***

9. ***Stroke severity has been defined in a variety of ways. Common definitions are unconsciousness with severe unilateral or bilateral paresis at onset; early FIM® score <40 or motor FIM® score <37; high risk for failure to return home due to physical, cognitive, perceptual, and communication difficulties, or a combination of the above.***

10. ***Severe strokes may be the most negatively affected by the type of funding models employed.***

11. ***It is currently unclear whether stroke type influences the extent of the benefits that the ICUs may offer.***

12. ***More severe strokes, as determined upon admission, are associated with poorer outcomes after rehabilitation when compared with less severe strokes.***

13. ***There is level 1a evidence that specialized interdisciplinary stroke rehabilitation reduces mortality in severe stroke patients when compared to general rehabilitation programs.***

14. ***There is level 1b and limited level 2 evidence suggesting that severe stroke patients who are admitted to specialized interdisciplinary stroke rehabilitation programs are more likely to be discharged home.***

15. ***There is conflicting level 1a and level 2 evidence regarding the effect of specialized interdisciplinary stroke rehabilitation programs on hospital length of stay.***

16. ***There is conflicting level 4 evidence regarding functional gains of persons with severe stroke following specialised interdisciplinary inpatient stroke rehabilitation.***

17. ***Functional outcomes suggest that rehabilitation of severe stroke patients should emphasize discharge planning and reduction of post-stroke complications.***

18. ***Some data suggest that slow-stream stroke rehabilitation may result in less favourable outcomes when compared to the more intensive stroke rehabilitation program.***

19. ***The utilization of slow stream rehabilitation should be dictated by the tolerance of the individual patient for therapy and not by preconceived notions about the amount of therapy that patients can successfully tolerate.***

20. ***More research needs to be conducted in the area of severe stroke prognosis.***

21. ***Trial treatments may assist in creating a more accurate basis for ethical decision-making.***

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