The recovery of walking ability and subclassification of stroke

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ABSTRACT **Background and Purpose**. *The recovery of walking after a stroke is a key functional goal for many patients. Reports vary, but approximately 50–80% of patients will regain some degree of walking ability following stroke (Skilbeck et al., 1983). There are few data available to show whether different subclassifications of stroke have distinct patterns of gait recovery. The present paper describes the pattern of walking recovery in a population of stroke patients classified according to the Oxfordshire Community Stroke Project classification (Bamford et al., 1991).* **Method**. *A prospective observational study. Stroke patients (*n *= 238) admitted to the inpatient Stroke Rehabilitation Unit at the Western General Hospital, Edinburgh were initially included, with data for 185 patients ultimately available for analysis. Standardized measures of recovery of 10 steps and a 10-metre walk were used routinely to examine recovery time of walking ability. The main outcome measures consisted of days taken to achieve a 10-step walk, days to achieve a 10-metre walk, and initial and discharge gait velocity over 10 metres.* **Results**. *Eighty-nine per cent of the sample (*n *= 164) achieved a 10-step walk in a median time of five days and a 10-metre walk in eight days. The median initial gait velocity was 0.45 m/s which improved by discharge to 0.55 m/s. Further analysis by subgroup revealed that subjects sustaining a partial anterior circulation infarct, lacunar infarct or posterior circulation infarct recovered significantly more quickly than those subjects with a total anterior circulation infarct (Kruskal Wallis test for days to achieve 10 steps (H = 22.524, N=164,* df *= 3)* p*<0.001; Kruskal Wallis test for days to achieve a 10-metre walk (H = 22.586, N=164,* df *= 3)* p*<0.001.* **Conclusions**. *An hierarchical pattern of recovery of gait was observed with definite variation between the subclassifications of stroke. It is suggested that further work needs to be undertaken to identify more accurately the factors that may influence the recovery of walking following stroke.*

Key words: gait, outcome measures, recovery, stroke

INTRODUCTION

Stroke is the third highest cause of death and a major cause of disability and handicap in adults (Khaw, 1996). Recovery of functional ability after stroke is variable, and between 30% and 60% of people remain dependent on others for some activities of daily living (Duncan et al., 1992). Key functional tasks, such as regaining the ability to walk, have been identified by patients as being of great significance (Bohannon, 1989; Bohannon et al., 1991). Approximately 50–80% of patients will regain some degree of walking ability after a stroke (Skilbeck et al., 1983), yet Hesse et al. (1994) argue that little is known about the exact nature of gait outcome following stroke. The present study therefore aimed to examine the recovery of walking function in patients with different stroke classifications.

Many studies which have investigated physical recovery after stroke do not differentiate between varying types and severity of lesion. Bamford et al. (1991) identified specific subtypes of cerebral infarction in the Oxfordshire Community Stroke Project (OCSP) and reported gross outcome. In the original paper, 543 patients were classified according to clinical presentations into standardized categories. These were described as follows:

- Total anterior circulation infarcts (TACI): 92 (17%).
- Partial anterior circulation infarcts (PACI): 185 (34%).
- Posterior circulation infarcts (POCI): 129 (24%).
- Lacunar infarcts (LACI): 137 (25%).

The outcomes of patients reported in this paper were limited to dead, dependent (Rankin score 3–5) or independent (Rankin score 0–2) at 30 days, six months and one year following stroke. Patients suffering TACI had a negligible chance of good functional outcome (4% independent at one year) and a high mortality related to the stroke, with 39% dying within 30 days and 60% dead at one year following the stroke. Patients with PACI were more likely to suffer a recurrent stroke and those with LACI were less likely to die as a result of the stroke, but could be left with profound lasting handicap despite the relatively small size of the infarct.

A number of studies have examined physical recovery following stroke in more depth. Partridge et al. (1993) in a prospective study of 348 stroke patients, found that at six weeks after stroke 65% of patients could take two steps forward and 56% achieved ‘independent walking inside’ (although it is not reported what distance was covered and how fast the patients could walk). Wade et al. (1985) reported that 10 days after stroke 42% of patients were independent in walking and by three months this had increased to 71%. However, the sample was relatively small, relating to 45 ‘core subjects’ out of an initial 99. Mobility was not tested directly but information was gathered from carers and nursing staff.

Normal gait velocity is variable, but is often estimated to be approximately 1–1.2 m/s. Gait speed in the elderly is generally slower, with mean velocities reported at around 0.7 m/s for older women aged 64–84 years (Finley et al., 1969). However, some studies have reported faster mean gait velocities in the elderly, for example 1.31 m/s for older women (mean age 64.3 years) and up to 1.41 m/s for older men (mean age 64.4 years) (Bohannon et al., 1996). Although reported as comfortable velocity, this could be argued to represent a moderate to fast speed of walking.

There is a functional significance to achievement of a certain walking velocity. Stroke subjects achieving a gait velocity of less than 0.25 m/s at time of discharge from hospital are reported to be more at risk of recurrent falls (Forster and Young, 1995). It has also been identified that hemiplegic subjects with gait velocities of less than 0.15 m/s are likely to end up in institutional care (Friedman, 1991). However, those stroke patients achieving a slightly faster walking speed, may still have problems in successful achievement of functional tasks, for example, crossing the road safely requires a velocity of approximately 1 m/s (Nelson et al., 1991).

Gait velocity following stroke has also been reported as a key indicator of functional status and clinical improvement (Roth et al., 1997). This argument should be viewed with caution as there is no strong evidence of a relationship between gait velocity and functional independence, for example independence in activities of daily living — particularly those activities requiring upper limb involvement such as dressing and eating. There is evidence, however, that gait velocity does correlate with walking independence and distance — which may be of importance with regard to the recovery of functional mobility (Bohannon, 1989).

Data for stroke subjects who achieve independent gait are variable with reports ranging from 0.23 m/s at six weeks post-stroke to 0.78 m/s at over three years post-stroke (see Table 1). This represents a reduction of approximately 25–75% of normal walking speed. However, these studies have not identified different subclassifications of stroke and the effects this may have on the heterogeneity of the group data.

The distance over which walking ability has been measured varies considerably, with reports of between two metres and 30 metres in the literature (Friedman, 1991; Roth et al., 1997; Witte and Carlsson, 1997). Although variable distances allow a number of gait parameters to be calculated, the use of a standardized 10-metre test is gaining popularity as it has been shown to be simple to use, valid and reliable, easy to communicate and potentially easy to standardize (Wade, 1992). Within a domestic setting, the ability to walk 10 metres may indicate functional independence around the home, although this may not be extrapolated to independence in the community (for example, ability to walk to the shops).

Although a number of studies have identified the time to recover walking ability

TABLE 1: Gait velocity measurements reported in 10 recent studies of hemiplegic subjects

Authors	*Number of subjects*	*Mean age (years)*	*Mean time since stroke*	*Mean gait velocity in m/s (SD)*
Burdett et al. (1988)	19	61.9	3.8 months	0.23 (0.11)
Richards et al. (1993)	27	Not reported	6 weeks	0.23–0.31*
Brandstater et al. (1983)	23	60–68†	2.5–4.7† months	0.31 (0.21)
Bohannon (1987)	37	Not reported	2 months	0.38 (0.26)
Roth et al. (1997)	25	56.2	At least 1 month post-stroke	0.43 (0.31)
Olney et al. (1994)	32	61	11 months	0.45 (0.2)
van Herk et al. (1998)	43	66	3.3 years	0.58
von Schroeder et al. (1995)	49	64.2	3.6 years	0.73 (0.38)
Nadeau et al. (1999)	16	47.9	43.9 months	0.76 (0.27)
Witte and Carlsson (1997)	18	54	At least 5.6 months post-stroke	0.78 (0.24)

*Range of velocity reported.
†Variable mean: sample subdivided into different stages of motor recovery.
SD = standard deviation.

post-stroke and the resultant walking speed achieved, no study was found to date that investigated the recovery of gait and gait velocity in relation to subclassification of strokes. This prospective study therefore aimed to examine whether different subclassifications of stroke had discrete patterns of achievement of walking and whether the gait velocity achieved differed depending on subclassification.

METHOD

Subjects

Two hundred and thirty-eight consecutive stroke patients admitted to the Western General Hospital, Edinburgh and assessed by the multidisciplinary stroke team between April 1995 and April 1997 were included in the present prospective descriptive study. All patients were identified according to the Oxford Community Stroke Project (OCSP) classification by the medical team (Bamford et al., 1991). Classification was confirmed by routine computerized tomography (CT) scanning to differentiate between infarct and haemorrhage. All patients underwent rehabilitation within a multidisciplinary team setting.

Procedure

Data relating to simple physical milestones of recovery were noted daily by the stroke team physiotherapists as part of normal clinical practice; this included recording the number of days (post-stroke) taken to walk 10 steps independently and the number of days to walk 10 metres independently (Smith and Baer, 1999). In addition, on first achievement of an independent 10-metre walk, an initial time was recorded, and this was repeated at discharge from physiotherapy. Data relating to subject characteristics of age, gender and stroke type were collected, as was length of hospital stay.

The standardized method of measuring 10 metres was as follows. Subjects commenced a single 10-metre walking test from a stationary standing start at the beginning of the walkway marked on the floor of the rehabilitation gym, and were instructed to walk at a comfortable speed to a point distant to the end of the marked 10-metre distance. Timing of the 10-metre walk was undertaken with a hand-held stopwatch and commenced at the beginning of the first step and ended as the subject crossed the line indicating 10 metres. For safety reasons, the assessor walked beside the subject on the affected side, but no manual assistance was allowed. Use of a walking aid was permitted if this was appropriate for the subject.

Data were analysed by use of the *Excel 5.0* and *SPSS 7.5* software packages. Time in days to achieve the walking milestones of 10 steps and 10 metres was recorded, as was time (in seconds) to complete a 10-metre walk. As some data for some subgroups were found to be positively skewed, median and mean values are presented to allow comparisons to be made.

RESULTS

Subject characteristics

Two hundred and thirty-eight patient records were available. Of these 238 subjects, 23 were classified as sustaining a primary intracerebral haemorrhage, a further 30 subjects died before walking milestones were achieved and therefore 185 records were available for analysis. Ninety-two subjects (49.7%) were male and 93 (50.3%) female with a mean age of 71.8 years (standard deviation (SD) 11.2 years). Subject characteristics by stroke classification are given in Table 2.

TABLE 2: Subject characteristics of stroke patients by OCSP classification

Stroke classification	*Number (%)*	*Mean (SD) age in years*	*Ratio male : female subjects*
PACI	74 (39.8)	73.6 (12.1)	41 : 33
LACI	48 (26)	70.0 (11.2)	24 : 24
POCI	36 (19.5)	70.5 (10.7)	17 : 19
TACI	27 (14.6)	71.7 (9.4)	10 : 17

SD = standard deviation; PACI = partial anterior circulation infarct; LACI = lacunar infarct; POCI = posterior circulation infarct; TACI = total anterior circulation infarct.

Of the 185 subjects, it may be seen that just under 90% (164) achieved 10 independent steps and an independent 10-metre walk. On further analysis, those classified as LACI, PACI and POCI achieved independent walking most rapidly (see Table 3). By use of a Kruskal Wallis test on the data for days taken to achieve 10 steps (H = 22.524, N=164, $df = 3$) the results were found to be significant at $p<0.001$ (Siegel and Castellan, 1988). Follow-up analysis between each of the subgroups using the procedure described by Siegel and Castellan (1988), found a significant difference only between the patients classified as TACI and all the other subclassifications. A Kruskal Wallis test on the data for days taken to achieve a 10-metre walk (H = 22.586, N=164, $df = 3$) found the results to be significant at $p<0.001$. Follow-up analysis between each of the subgroups again found a significant difference only between the patients classified as TACI and all the other subclassifications (Siegel and Castellan, 1988).

It was interesting to note that the median initial time for all subjects to achieve a 10-metre walk was 22 seconds (gait velocity 0.45 m/s) with a final time on discharge of 18 seconds (0.55 m/s). Full walking speed data were unavailable for five subjects (three PACI, two LACI), although this was found not to affect the results significantly and the median improvement in discharge walking time was no more than four seconds for any subclassification. Figure 1

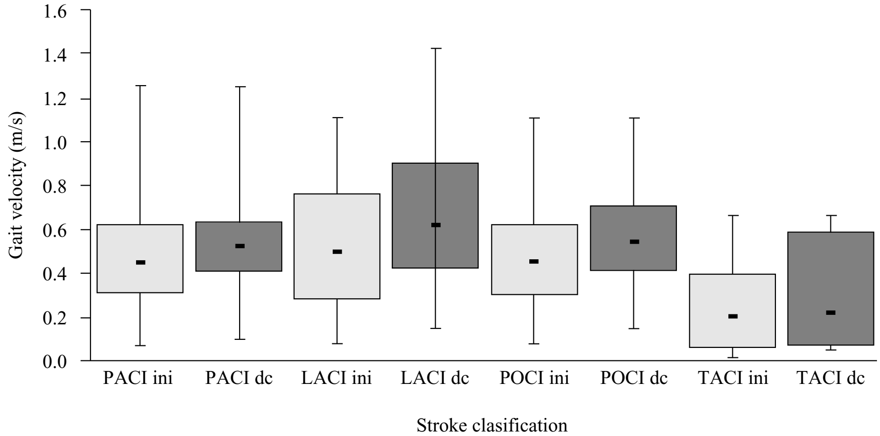

FIGURE 1: Initial and discharge gait velocities over a 10-metre walk; ini = initial, dc = discharge.

TABLE 3: Percentage of subjects achieving independent walking (in days) and the times taken for initial and final 10-m walk (in seconds)

	All (n = *185)*	*PACI* (n = *74)*	*LACI* (n = *48)*	*POCI* (n = *36)*	*TACI* (n = *27)*
Independent walking					
10 steps					
n (%)	*n* = 164 (88.7)	*n* = 71 (96)	*n* = 48 (100)	*n* = 35 (97.2)	*n* = 10 (37)
median (IQR)	5 (2–14)	5 (2–11.5)	4 (2–8.25)	4 (2–14.5)	59.5 (33.5–127.5)
mean (SD)	16.0 (29.7)	12 (18.7)	8.4 (11.1)	14.7 (26.0)	84.7 (66.2)
10-m walk					
n (%)	*n* = 164 (88.7)	*n* = 71 (96)	*n* = 48 (100)	*n* = 35 (97.2)	*n* = 10 (37)
median (IQR)	8 (3–25)	6 (3–19.5)	8 (3–15)	9 (4–26)	81.5 (39.75–176.5)
mean (SD)	22.4 (37.9)	18.8 (32)	11.4 (12.6)	21.0 (28.5)	105.5 (75.3)
Times taken					
Initial 10-m walk					
median (IQR)	22 (16–38.5)	22 (16–32.25)	20 (13–35.5)	22 (16–33)	46.5 (25–152.75)
mean (SD)	36.4 (50.0)	31.4 (27.1)	29.3 (23.6)	29.6 (22.7)	126.2 (155.2)
Final 10-m walk					
median (IQR)	18 (14–26)	19 (15.75–24.5)	16 (11–23.5)	18 (14–24)	44.5 (16.75–130.25)
mean (SD)	24.9 (24.5)	22.6 (14.8)	21 (13.9)	21.5 (11.4)	71.4 (70.1)

IQR = Interquartile range; SD = standard deviation; PACI = partial anterior circulation infarct; LACI = lacunar infarct; POCI = posterior circulation infarct; TACI = total anterior circulation infarct.

illustrates the initial and discharge gait velocities of each subgroup. By use of a Kruskal Wallis test on the data for walking speed on initial achievement of the 10-metre walk (H = 7.135, N = 159, *df* = 3) no significant difference was found between the groups ($p>0.05$). However, a Kruskal Wallis test performed on the data for 10-metre walking speed on discharge (H = 8.991, N=159, *df* = 3) found a significant difference between the groups at $p<0.05$. Follow-up analysis between subjects in each subgroup found a significant difference only between the patients classified as TACI and all the other subclassifications (Siegel and Castellan, 1988).

Data were also collected for the number of subjects using a walking aid (see Table 4).

DISCUSSION

The population studied here is relatively large in comparison to much of the published literature relating to hemiplegic gait recovery. Although the sample population was limited to one clinical site, the subject characteristics appear to reflect a fairly typical hospital-based stroke population (Wade et al., 1987) and therefore allows some conclusions to be inferred from the data with regard to the recovery of walking ability and stroke subclassification.

In comparison to a previous study on a similar population (Smith and Baer, 1999), the outcomes of this cohort were slightly better. Overall, just under 90% of this surviving stroke population achieved independence in walking 10 steps or 10 metres. This is similar to the achievement rates in populations previously described (Wade et al., 1985; Smith and Baer, 1999). A limitation of the present study is that walking was solely tested indoors on a smooth surface, and the achievement rate may alter if testing had included outdoor mobility and the ability to negotiate different surfaces. Furthermore, the data may be slightly skewed as this was a specific inpatient population from one site, haemorrhagic strokes had been excluded and patients that had died were excluded from statistical analysis.

The median time taken to achieve 10 steps independently across the whole sample was five days, with 75% of the sample achieving this goal in 14 days. The subgroup classified as TACI demonstrated a much poorer outcome. Only 10 subjects (37%) achieved this goal, and those that did manage 10 steps took a median time of nearly two months to do so.

A similar pattern was evident for achievement of an independent 10-metre walk. Overall, nearly 89% of the sample achieved this mobility milestone in a

TABLE 4: Percentage of subjects who required a walking aid

Stroke classification	*Number (%) achieving independent 10-m walk*	*Number (%) using walking aid*	*Type of aid*	
			Zimmer frame	*Stick*
PACI (*n* = 74)	71 (96)	12 (16.2)	4	8
LACI (*n* = 48)	48 (100)	7 (14.6)	3	4
POCI (*n* = 36)	35 (97.2)	6 (16.7)	2	4
TACI (*n* = 27)	10 (37)	3 (11.1)	1	2

PACI = partial anterior circulation infarct; LACI = lacunar infarct; POCI = posterior circulation infarct; TACI = total anterior circulation infarct.

median time of eight days, and 75% of the sample achieved a 10-metre walk within 25 days. The TACI group however, took much longer. Only 10 subjects (37%) achieved this milestone with a median time to achievement of just under three months. Performance was varied as can be seen from the interquartile range (IQR) 39.75–176.5. It has previously been argued that this presents a considerable clinical dilemma as it may be very difficult to predict which individuals within the TACI group are most likely to be successful in attaining independent ambulation and that co-existing visuospatial and cognitive dysfunction associated with TACI negatively affects outcome (Smith and Baer, 1999). This may, in part, explain why 17 of the TACI group did not achieve any walking recovery. These findings concur with work by Sánchez-Blanco et al. (1999), who found that patients with pure motor strokes had a probability 5.4 times higher of achieving independent walking than a patient who suffered a stroke with combined motor, sensory and visual symptoms.

The gait velocity calculated for this population overall was 0.45 m/s on initial achievement of an independent 10-metre walk. This increased by discharge to 0.55 m/s. These times are less than half of those reported for normal elderly subjects (Bohannon et al., 1996) and presumably would have a major negative impact on ability to achieve certain functional tasks safely (for example, crossing a road). It is worth noting the considerable range of walking speed achieved by the different subclassifications. The fastest median initial 10-metre gait velocity was 0.5 m/s, demonstrated by the LACI subgroup which improved to 0.63 m/s at discharge. The TACI group exhibited an initial speed of 0.22 m/s, which did not improve by discharge and therefore this subgroup appears to be at a higher risk of failing to achieve functional mobility coupled with an increased risk of falling (Friedman, 1991; Forster and Young, 1995).

From this population, it was found that approximately one-sixth of stroke patients required either a Zimmer walking frame or a stick for ambulation. This probably reflects quite a low percentage of patients requiring a walking aid, as Witte and Carlsson (1997) reported 33% of their population to use a cane when walking. Our findings may be related to the fact that the majority of subjects were inpatients for the duration of the study and were encouraged to regain indoor walking ability with the minimal use of assistive devices. It was observed that a higher proportion of TACI patients (approximately 30% of those that did walk) required a walking aid and it would be interesting to investigate further whether the use of walking aids influences walking speed. One might expect to see a marked increase in walking aid use if the subjects had recovered to the stage of achieving safe outdoor walking.

CONCLUSIONS

In this study approximately 90% of surviving hemiplegic subjects achieved some level of independence in walking. Analyses revealed that those subjects subclassified as TACI had a poorer outcome than other subgroups of stroke. These findings have implications for the process of rehabilitation. We have found that the routine collection of simple outcome data has provided a basis for clinical decision-making, goal-setting and treatment planning.

It is suggested that future work should be conducted to identify what factors may be associated with successful achievement of gait after stroke and in particular whether specific factors can be identified in TACI patients that will result in a positive outcome.

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