

Possibility of Independence in ADL (Activities of Daily Living) for Patients with Cervical Spinal Cord Injuries - An Evaluation based on the Zancolli Classification of Residual Arm Functions

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ABSTRACT

For patients with cervical spinal cord injuries to become independent in their ADL (Activities of Daily Living), residual arm function is very important. Also, age, sex, physical strength, obesity, spasticity, pain, contracture and motivation are related. We investigated the possibility of independence in ADL for patients with cervical spinal cord injuries, carrying out our evaluation based on the Zancolli Classification of Residual Arm Functions. Zancolli classification C6BII is taken as the boundary level for ADL independence. Rehabilitation is not only controlled by the patients with cervical spinal cord injuries themselves but also by the ability of the rehabilitation staff. This implies that taking responsibility in rehabilitation is important.

Key words: *Cervical spinal cord injuries, Activities of Daily Living, Zancolli classification*

ADL restrictions for cervical spinal cord injuries are determined by where the injury is on the spinal cord. However, there are big differences between individuals such as age differences. Since Long's report⁵⁾, there have been many reports on the goals attained by patients with spinal injuries in terms of ADL^{1,4)}. However, none of these can be generalized as specific attainable goals (they weren't universally applicable). We analyzed the attainable goals of patients with spinal injuries for ADL by using the Zancolli classification⁶⁾ of spinal injuries.

MATERIALS AND METHODS

We studied 117 cases of cervical spinal cord injuries resulting in complete paralysis, of these 89 were males and 28 were females. The ages ranged from 18 to 67 (average age was 47.5). Evaluation was performed at the time of completion of rehabilitation, which means at the time of discharge from the hospital, and was 31 to 71 weeks (average 41 weeks) following the injury. The classification of residual levels showed 15 cases of C4, 14 cases of C5A, 13 cases of C5B, 8 cases of C6A, 17 cases of C6BI, 31 cases of C6BII, 6 cases of C6BIII, 3 cases of C7A, 5 cases of C7B, 1 case of C8A, and 4 cases of C8B.

The Zancolli classification (Table 1) was contrived for making decisions on and the adoption of arm function rebuilding methods for patients with cervical spinal cord injuries with quadriplegia.

Especially, attention was given to C6 (motor function C6 remains) which occurs more frequently than any of the other cases. Working to rebuild thumb/forefinger lateral pinch, groups were divided into subgroups A and B, and then subgroup B was further divided into three groups. However, in the Zancolli classification, it is not clear where the dividing line between levels is for the evaluation of the manual muscle test of residual muscle which is the basis of the level classification. Therefore, we decided to use the standard points of reference as shown below.

- (1) Muscle strength of the biceps is poor or better, level C5A.
- (2) Brachioradialis is fair or better, level C5B.
- (3) Extensor carpi radialis is poor or better, level C6A.
- (4) Extensor carpi radialis is good or better, level C6BII
- (5) Pronator teres is poor or better, level C6BII.
- (6) Flexor carpi radialis and triceps are poor, level C6BIII.
- (7) Extensor digitorum communis is poor or better, level is C7A.
- (8) Extensor digitorum communis is fair or better. Also the extensor pollicis longus is poor or better, level C7B.
- (9) Flexor digitorum profundus is poor or better, level C8A.
- (10) Flexor digitorum profundus is fair or better. Also the flexor pollicis longus is poor or better,

Table 1. The Zancolli classification

Group	Lowest Functioning Cord Segments	Remaining Motor Function	Subgroups	
1. Flexor of the elbow	5~6	Biceps, brachialis	A	Without brachioradialis
			B	With brachioradialis
2. Extensor of the wrist	6~7	Extensor carpi radialis longus and brevis	A	Weak and complete wrist extension
			B	Strong wrist extension
				I. Without pronator teres, flexor carpi radialis, and triceps II. Without flexor carpi radialis and triceps; and with pronator teres III. With pronator teres, flexor carpi radialis and triceps
3. Extrinsic extensor of the fingers	7~8	Ext. digit. communis Ext. digit. quinti Ext. carpi. ulnaris	A	Complete extension of ulnar fingers and paralysis of radial fingers and thumb
			B	Complete extension of all fingers and weak thumb extension
4. Extrinsic flexor of the fingers and extensor of the thumb	8~9	Flexor digit. prof. Ext. indicis proprius Ext. pollicis longus Flexor carpi ulnaris	A	Complete flexion of ulnar fingers and paralysis or weakness of flexion of the radial fingers and thumb. Complete thumb extension
			B	Complete flexion of the fingers and thumb, with total intrinsic paralysis
				I. Without flexor superficialis II. With flexor superficialis

level C8B, but the intrinsic muscle is poor or worse.

RESULTS

Our ADL table consisted of 10 items: wheel chair maneuverability, transfer ability, bed mobility and transfer, eating, dressing, grooming, communication, bathing, bladder management, and bowel management. Each item was classified in 5 levels as to the possibility of independence:

3 : completely independent

2 : independent with aid of device or splint

(2): independent with aid of tools or equipment

1 : needs some assistance

0 : completely dependent

Possibility of Independence for Patients with Residual Function for each ADL Item

(1) Wheelchair maneuverability

The C6A level aimed for independence in ascent and descent on slopes with an inclination of 4 degrees and C6BIII aimed to balance the chair on its rear wheels and to push it over a 3cm high obstruction.

(2) Transfer

C6BI and C6BII could transfer between their wheelchair and a toilet for people with quadriplegia which was fitted with a board and chair back cut to allow for wheelchair access with no gaps. C6BIII were able to move between the wheelchair

and the washing place in the bathroom and also by taking into account the hand rail position and the depth of the bath, it was possible for them to transfer between the washing place and the bathtub. Transfer between the wheelchair and a car was possible at the C6BII level by using a transfer board and by balancing with the head and both limbs.

(3) Bed mobility and transfer

C6A could transfer to the bed by holding the bed railing and moving from a long sitting position to a supine one. C6BII could move using the bed railing and/or sling of the blanket frame to enable them to turn from side to side and to sit up from the supine to the long sitting position. C6BIII could perform an elbow stretch while lying on the side.

(4) Eating (Fig.1)

It was partially possible for C5A to eat by using balanced forearm orthosis (BFO) and cock up splint. C6A could hold a cup with both hands. C6BI could move tableware well. C8B found it impossible to use chopsticks normally because of the decreased muscle strength of the intrinsic muscles.

(5) Dressing

C6A could put on and take off pullover garments and pull up and down a zipper fitted with a pull-ring. C6BI could put on and take off shoes with a

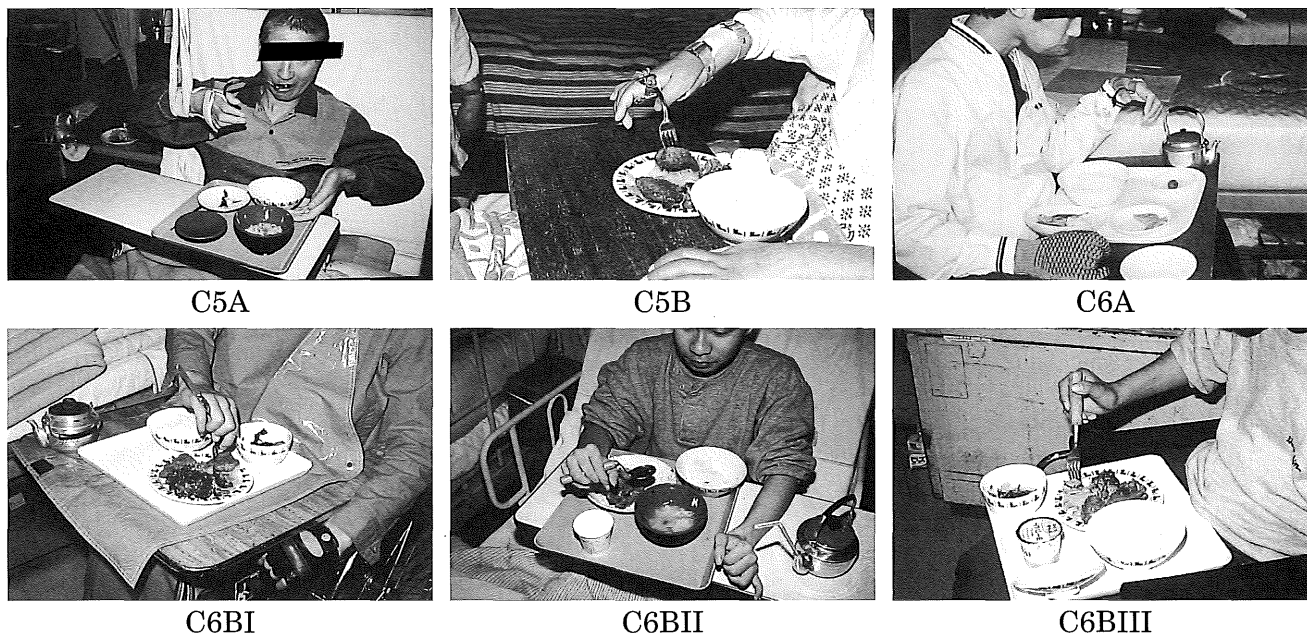


Fig. 1. To eat with a spoon and fork

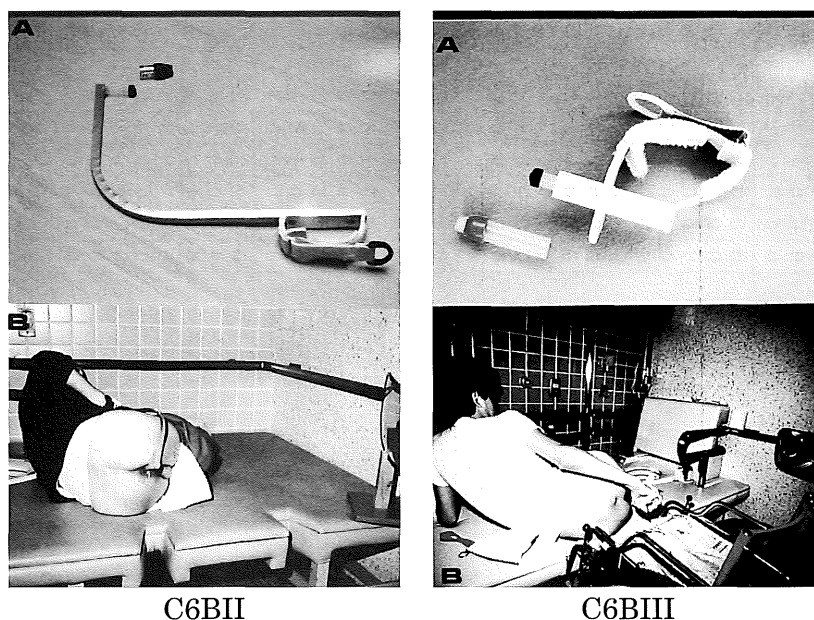


Fig. 2. To insert suppository into the bowel using the tool

pull-ring. C6BII could put on and take off pants fitted with loops. It was difficult to fasten and unfasten buttons even at the C8B level.

(6) Grooming

C5B could brush teeth by using a device and cock up splint and shave partially with an electric razor. C6BI could put the toothbrush in the cuff and brush the teeth. Also this level could put an electric razor into a holder and shave and cut their fingernails with a nail cutter fixed to a board. C6BIII could shave by holding an electric razor with both hands.

(7) Communication

C4 could use an environmental control system

(ECS) and a speaker phone and could turn book pages with a mouth stick. C5A could operate a keyboard by putting on a BFO and a cock up splint. C5B could write with a writing cock up splint. C6A could use a push button type phone. Keyboard operation in the C6BI level required use of a device while C6BIII level did not need such a device.

(8) Bathing

C6BI could use a hairdryer with a holder. C6BII had difficulty washing the body well but C6BIII could wash the body using a towel fitted with loops. Also this level could wash the buttocks while lying on the side and, by supporting the

Table 2. Possibility of Independence for Patients with Residual Function for each ADI Item

		C4	C5	C5	C6	C6	C6	C6	C7	C7	C8	C8	Devices, others
		A	B	A	B	B	B	A	B	A	B		
(1) Wheelchair maneuver	① To go forward indoors	0	1	2	2	3	3	3	3	3	3	3	
	② To turn the chair at a corner	0	1	2	2	3	3	3	3	3	3	3	
	③ To go backward	0	1	2	2	3	3	3	3	3	3	3	
	④ To manipulate the breaks	0	1	2	2	3	3	3	3	3	3	3	
	⑤ To maintain sitting position on the chair	2	2	2	3	3	3	3	3	3	3	3	
	⑥ To change position on the seat	0	0	1	1	3	3	3	3	3	3	3	
	⑦ To manoeuvre the wheelchair outdoors (asphalted roads)	0	0	2	2	3	3	3	3	3	3	3	
	⑧ To ascend and descend a slope (an inclination of 4 degrees)	0	0	0	3	3	3	3	3	3	3	3	
	⑨ To push the chair over a 3 cm step	0	0	0	1	3	3	3	3	3	3	3	
	⑩ To balance the chair on the rear wheels	0	0	0	0	1	1	3	3	3	3	3	
(2) Transfer	① Wheelchair to bed	0	0	0	2	2	2	3	3	3	3	3	Transfer board
	② Bed to wheelchair	0	0	0	1	2	2	3	3	3	3	3	
	③ Wheelchair to toilet seat	0	0	0	(2)	(2)	(2)	3	3	3	3	3	Toilet for people with quadriplegia
	④ Toilet seat to wheelchair	0	0	0	1	(2)	(2)	3	3	3	3	3	Toilet for people with quadriplegia
	⑤ Wheelchair to washing place in the bathroom	0	0	0	(2)	(2)	(2)	3	3	3	3	3	A board that is the same height as the wheelchair
	⑥ Washing place in the bath room to wheelchair	0	0	0	1	(2)	(2)	3	3	3	3	3	A board that is the same height as the wheelchair
	⑦ Washing place to bathtub	0	0	0	0	0	0	3	3	3	3	3	
	⑧ Bath tub to washing place	0	0	0	0	0	0	3	3	3	3	3	
	⑨ Wheelchair to car	0	0	0	0	2	2	3	3	3	3	3	
	⑩ Car to wheelchair	0	0	0	0	2	2	3	3	3	3	3	
	⑪ Wheelchair to floor	0	0	0	0	0	0	1	3	3	3	3	
	⑫ Floor to wheelchair	0	0	0	0	0	0	1	3	3	3	3	
(3) Bed Mobility and Transfer	① To move from prone to side lying	0	1	2	2	2	2	2	2	2	2	2	
	② To move from supine to prone	0	0	0	3	3	3	3	3	3	3	3	
	③ To move from supine to long sitting	0	0	1	1	2	2	2	2	2	2	2	
	④ To move from long sitting to supine	0	0	0	0	3	3	3	3	3	3	3	
	⑤ To maintain long sitting	0	0	0	0	0	0	3	3	3	3	3	
	⑥ To maintain side lying	0	1	2	3	3	3	3	3	3	3	3	
	⑦ To move from prone to all fours	0	0	0	1	3	3	3	3	3	3	3	
	⑧ To move from sitting in the wheelchair to standing	0	0	0	0	0	0	0	0	0	2	2	standing table, devices for standing
(4) Eating	① To eat with a spoon and fork	0	1	2	2	2	2	2	2	2	2	2	
	② To drink with glass or cup	0	0	0	3	3	3	3	3	3	3	3	
	③ To cut food	0	0	1	1	2	2	2	2	2	2	2	
	④ To pour tea into a cup	0	0	0	0	3	3	3	3	3	3	3	
	⑤ To open a bottle or box	0	0	0	0	0	0	3	3	3	3	3	
	⑥ To eat snack (bread)	0	1	2	3	3	3	3	3	3	3	3	
	⑦ To move table wear	0	0	0	1	3	3	3	3	3	3	3	
	⑧ To use chopsticks	0	0	0	0	0	0	0	0	0	2	2	
(5) Dressing	① To put in pullover garment	0	0	0	3	3	3	3	3	3	3	3	
	② To take off pullover garment	0	0	0	3	3	3	3	3	3	3	3	
	③ To put on pants	0	0	0	0	2	2	3	3	3	3	3	
	④ To take off pants	0	0	0	0	2	2	3	3	3	3	3	
	⑤ To put on socks	0	0	0	0	2	2	3	3	3	3	3	
	⑥ To take off socks	0	0	0	0	2	2	3	3	3	3	3	
	⑦ To put on shoes	0	0	0	0	2	2	3	3	3	3	3	
	⑧ To take off shoes	0	0	0	0	2	2	3	3	3	3	3	
	⑨ To pull up a zipper	0	0	0	2	2	2	2	2	2	2	2	
	⑩ To pull down a zipper	0	0	0	2	2	2	2	2	2	2	2	
	⑪ To fasten a button	0	0	0	0	0	0	0	0	0	0	1	
	⑫ To unfasten a button	0	0	0	0	0	0	0	0	0	0	1	

(6) Grooming	① To brush teeth	0	0	2	2	2	2	2	2	2	3	3	
	② To comb hair	0	0	2	2	2	2	3	3	3	3	3	
	③ To shave face	0	0	1	1	2	2	3	3	3	3	3	
	④ To wash face and hands	0	0	1	1	3	3	3	3	3	3	3	
	⑤ To cut finger nails	0	0	0	0	2	2	3	3	3	3	3	
	⑥ To pick up a tissue paper from a box	0	0	3	3	3	3	3	3	3	3	3	
(7) communication	① To turn pages	1	2	2	3	3	3	3	3	3	3	3	
	② To write	0	0	2	2	2	2	2	2	2	3	3	
	③ To manipulate a phone and dials	0	0	2	3	3	3	3	3	3	3	3	
	④ To manipulate a letter (open and close the envelope)	0	0	0	0	2	2	2	3	3	3	3	
	⑤ To manipulate a keyboard	1	1	2	2	2	2	3	3	3	3	3	
(8) Bathing	① To wash upper body	0	0	0	0	1	1	2	2	2	2	2	
	② To dry upper body	0	0	0	0	1	1	2	2	2	2	2	
	③ To wash lower body	0	0	0	0	1	1	2	2	2	2	2	
	④ To dry lower body	0	0	0	0	1	1	2	2	2	2	2	
	⑤ To wash face	0	0	0	1	3	3	3	3	3	3	3	
	⑥ To dry face	0	0	0	3	3	3	3	3	3	3	3	
	⑦ To wash hair	0	0	0	0	0	0	3	3	3	3	3	
	⑧ To dry hair	0	0	0	0	0	0	3	3	3	3	3	
	⑨ To use shower	0	0	0	0	1	1	3	3	3	3	3	
	⑩ To dry hair with hair dryer	0	0	0	0	2	2	3	3	3	3	3	
(9) Bladder Management Using catheter	① To put a urinal bottle between knees	0	0	0	2	2	2	2	2	2	2	2	
	② To expose the urethra from the clothes and clean up	0	0	0	2	2	2	2	2	2	2	2	
	③ To pick up catheter and insert it into the urethra	0	0	0	2	2	2	3	3	3	3	3	
	④ Insert the catheter by hand	0	0	0	2	2	2	3	3	3	3	3	
	⑤ To pull out catheter and return it to the case	0	0	0	2	2	2	3	3	3	3	3	
	⑥ To push in the catheter and to pass water	0	0	0	2	2	2	3	3	3	3	3	
	⑦ To wash the catheter with tap water and return it to the case	0	0	0	2	2	2	3	3	3	3	3	
	⑧ To pour the urine in the bottle into the toilet	0	0	0	0	3	3	3	3	3	3	3	
(10) Bladder Management Using bladder bag	① To roll up the condom	0	0	0	0	1	1	2	2	2	3	3	
	② To roll condom on to penis	0	0	0	0	1	1	3	3	3	3	3	
	③ To roll condom off from penis	0	0	0	3	3	3	3	3	3	3	3	
	④ To fix the condom by tool to penis	0	0	0	0	2	2	2	2	2	2	2	
	⑤ To unfix tool from the penis	0	0	0	3	3	3	3	3	3	3	3	
	⑥ To fix the urinal bag to the garter	0	0	0	0	2	2	3	3	3	3	3	
	⑦ To unfix the urinal bag from the garter	0	0	0	1	2	2	3	3	3	3	3	
	⑧ To fix the garter to the shin	0	0	0	0	2	2	3	3	3	3	3	
	⑨ To unfix the garter from the shin	0	0	0	0	2	2	3	3	3	3	3	
	⑩ To fix belt for tube to thigh	0	0	0	0	2	2	3	3	3	3	3	
	⑪ To unfix belt for tube from thigh	0	0	0	2	2	2	3	3	3	3	3	
	⑫ To flow urine into the urinal bag	0	0	0	0	2	2	3	3	3	3	3	
(11) Bowel Management, Using suppository	① To remove the suppository	0	0	0	0	0	0	2	2	2	2	2	Toilet for quadriplegia with back
	② To transfer to western style toilet	0	0	0	(2)	(2)	(2)	3	3	3	3	3	Toilet for quadriplegia with back
	③ To remove pants and underwear	0	0	0	0	(2)	(2)	3	3	3	3	3	
	④ To put the suppository in the tool	0	0	0	3	3	3	3	3	3	3	3	
	⑤ To insert the suppository into the bowel using the tool	0	0	0	0	3	3	3	3	3	3	3	
	⑥ To repeat massage on abdomen while sitting on the toilet	0	0	0	3	3	3	3	3	3	3	3	
	⑦ To clean the buttocks	0	0	0	(2)	(2)	(2)	3	3	3	3	3	automatic washing tool for buttocks
	⑧ To put on pants and underwear at the toilet	0	0	0	0	1	1	3	3	3	3	3	
	⑨ To transfer to wheelchair from toilet	0	0	0	1	(2)	(2)	3	3	3	3	3	Toilet for people with quadriplegia

3: completely independent 2: independent with device or splint (2): independent with tools or machine 1: needs some assistance 0: completely dependent

body on a chair back in the long sitting position, could wash the hair with a hair brush.

(9) Bladder Management

1) self catheterization

C6A could pick up the catheter from the disinfection container and insert it properly. There was a possibility of self-catheterization activity, but women even in the C6BII level have difficulty without the addition of some equipment or device.

2) bladder massage

C6BII could fix and unfix the tool for the condom, could fix the urinal bag on the shin, and could dispose of the urine in the urinal bag making use of a device. C6BIII could roll up a condom.

(10) Bowel Management (Fig.2)

By using a toilet for quadriplegia patients, depending on the level of the marrow joint injury, it was possible to be independent but it was a difficult ADL, along with bladder management, to be independent in. C6BII could insert a suppository into the bowel by using a tool but cleaning the buttocks was difficult. C6BIII could remove the suppository from its plastic case and could also clean the buttocks from a position lying on the side. When there was no sensation around the anal opening a mirror could be use.

DISCUSSION

Recently, in the classification of spinal cord injuries, the Frankel classification³⁾ and ASIA (American Spinal Injury Association) classification²⁾ have been used often. However, the Frankel classification is a perfunctory classification in which each classification has only five levels. ASIA has the characteristics of both injury classification and ADL limitations. However, this classification system has problems such as in the case of C7 injuries, where patients who can live independently with a wheelchair are given lower points than patients with cervical spinal imperfect injuries, such as those with central spinal cord injuries who need assistance for wheelchair life.

The Zancolli classification was originally designed for reconstructing the function of hands paralyzed due to cervical spinal cord injuries, and it is only for complete paralysis. There are problems with this system as well, such as there being no evaluation of sense disorder, but it has characteristics which none of the other classification systems have. It is a more precise injury classification system. That is, C6 injuries are given four more clas-

sification levels. According to our classification of ADL attainable goals under the Zancolli classification, we found that the boundary of ADL independence using a wheelchair is C6BII, which is a much higher level than C7, which used to be the indication of the possibility for independence using a wheelchair (Table 2). Not all C6BII can lead an independent life with a wheelchair, however, and to realize the ADL attainable goal rehabilitation staff should put in every effort.

Rehabilitation for cervical spinal injuries aims to create independence in each item of ADL by setting goals according to the residual function, preparing the proper environment and then adding the necessary devices. Search for the proper rehabilitation method for each individual case, such as hand position, compensatory action, and counter movement, is necessary. By repeating daily, the time can be shortened, ability improved, and fatigue lessened. However, the above mentioned goals are only possibilities and cannot be reached in all cases.

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