

Original Article

# Rehabilitation for patients with paraplegia and lower extremity amputation

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**Abstract.** [Purpose] To study the characteristics and treatment strategy for patients with paraplegia and lower extremity amputation. [Subjects] Six cases were selected from among the patients admitted to the China Rehabilitation Research Center from 1991 to 2014. The criteria for the six cases were spinal cord injury with amputation immediately or in a short time (1 week) after the trauma. [Methods] General information, clinical diagnosis, treatment, rehabilitation and other data were analyzed. [Results] All the six cases were injured by high energy or complex energy accidents: two cases by falls after high voltage electric shock, one by an oil pipeline explosion, one by the impact of a falling tower crane and received high energy traffic accident injuries (one was hit by a train, and the other was hit by a truck at high speed). All the six cases had thoracic and lumbar vertebral injuries and complete paraplegia. Amputation stump infection occurred in four cases. After comprehensive rehabilitation treatment, patients' functional independence measure (FIM) scores improved significantly, but American Spinal Injury Association (ASIA) scores and ASIA Impairment Scale (AIS) grades showed no significant improvement. [Conclusion] When formulating the clinical treatment and rehabilitation for spinal cord injury with amputation patients, simultaneous consideration of the characteristics of the spinal cord injury and amputation is needed to develop an individualized strategy. For spinal cord injury with limb amputation patients, prostheses should allow the improvement of patients' self-care ability.

**Key words:** Paraplegia, Amputation, Rehabilitation

(This article was submitted May 25, 2015, and was accepted Jul. 2, 2015)

## INTRODUCTION

Paraplegia with lower extremity amputation is rare in clinical practice. Most of the cases have injuries caused by high energy or complex energy trauma. In recent years, dual disability caused by paraplegia and amputation has increased every year with the development of the Chinese economy and technology. Due to the improvement of clinical treatment, the survival rates of the patients have increased, which poses a new challenge for clinical and rehabilitation medicine. This study analyzed cases of paraplegia with lower extremity amputation admitted to the China Rehabilitation Research Center from 1991 to 2014 to provide reference for clinical and rehabilitation treatments.

## SUBJECTS AND METHODS

Six paraplegia cases with lower extremity amputation admitted to the China Rehabilitation Research Center from

1991 to 2011 met the inclusion criteria of the study. Before rehabilitation, the cases were first evaluated by a rehabilitation team consisting of an orthopedic doctor, a rehabilitation doctor, rehabilitation nurses, prostheses and orthoses engineers, physical therapists (PTs), occupational therapists (OTs), psychological doctors, et al. The ethical committee in China Rehabilitation Research Center has approved the studies and that written informed consent has been obtained from each subject or patient.

The characteristics of the 6 cases are summarized below and in Table 1.

Case 1 was a female railroad worker aged 36 years old. Two days after being hit by a train, her right thigh was amputated at the upper 1/3. One week after the injury, her spine was fixed by a pedicle screw system because of L1 fracture. The sensory level was L2 and the AIS grade was A. Key muscle powers were all grade 0 for the lower extremities (Table 1).

Case 2 was a female worker aged 40 years old. An oil pipeline explosion caused thoracolumbar vertebral fracture with open injury of the right leg. Her right thigh was amputated and the thoracic and lumbar spine segments were internally fixed. The sensory level was T10 and the AIS grade was A. Key muscle powers were all grade 0 for the lower extremities (Table 1).

Case 3 was a female patient aged 30 years old. She was injured by a high speed truck. Seven days after trauma, her

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**Table 1.** General characteristics of the patients and spinal cord injury

Patient no.	Gender	Age (years)	Occupation	Injury causes	Spine injury segment	Spine injury type	Spinal fracture type (Denis)	Level of spinal cord injury	Degree of spinal cord injury	Operation time of spine (days after injury)	Operation method of spine
1	F	36	railroad worker	Train hit	TL	close	BF	L1	A	7	PSSPLS
2	F	40	worker	Oil pipeline explosion	TL	open	BF	T10	A	8	PSSPLS
3	F	44	self-employed	truck hit	TL	close	FD	T9	A	7	Luque rod system
4	M	42	worker	Crane crush	TL	close	FD	T11	A	3	PSSPLS
5	M	20	electrician	HVESF	TL	close	BF	T10	A	30	PSSPLS
6	M	47	electrician	HVESF	TL	close	BF	T9	A	4	PSSPLS

F: female; M: male; HVESF: high-voltage electric shock and fall; TL: thoracolumbar; BF: burst fracture; FD: fracture and dislocation; PSSPLS: pedicle screw system of posterior long segment

**Table 2.** Characteristics of amputation and related conditions

Patient no.	Amputation location	Amputation time (days after trauma)	Stump condition	Compound injury	Phantom limb pain	Neuropathic pain	Bone mineral density (T value)	Ischial tuberosity pressure (mmHg)
1	1/3 of UMRT	2	poor healing of grafting	hip dislocation, right and left ankle fractures, multiple rib fractures	Y	Y	-2.2SD	80
2	1/3 of UMRT	2	skin deficiency	early stage shock	Y	Y	0.0SD	50
3	1/3 of MLLT	0	infection	left femoral shaft fractures	Y	N	-5.6SD	75
4	1/3 of UMRC	0	tibial plateau fractures, ligament and meniscus injury	pleural effusion	Y	Y	-3.3SD	95
5	1/3 of MLLT	8	splenic rupture	tracheal collapse	N	N	-2.4 SD	68
6	1/3 of MLRC	2	No special	No special	Y	Y	-4.5SD	100

UMRT: upper and middle of right thigh; MLLT: middle and lower of left thigh; UMRC: upper and middle of right calf; MLRC: middle and lower of right calf; Y: yes; N: no

spine was fixed by internal fixation. The sensory level was T9 and the AIS grade was A. Key muscle powers were all grade 0 for the lower extremities (Table 1).

Case 4 was a male worker aged 42 years old. He was hit by a tower crane, which caused thoracolumbar fracture and led to right calf amputation. His spine was fixed from T9 to L3. The sensory level was T11 and the AIS grade was A. Key muscle powers were all grade 0 for the lower extremities (Table 1).

Case 5 was a male electrician aged 20 years old. He fell from a height of 12 meters after receiving a high-voltage electric shock. His spine was fixed from T12 to L3. The sensory level was T10 and the AIS grade was A. Key muscle powers were all grade 0 for the lower extremities (Table 1).

Case 6 was a male electrician aged 47 years old. He fell from a height of 6 meters after receiving a high-voltage electric shock. His spine was fixed from T11 to L2. The sensory level was T9 and the AIS grade was A. Key muscle powers were all grade 0 for the lower extremities (Table 1).

## RESULTS

This series included three men and three women with an average age of 36 years old (range 20–47). All the patients were injured by high energy trauma. Mechanisms of injury included accidents due to falls after high-voltage electric shock (two), high energy traffic accident (two: hit by a train or high speed truck), oil pipeline explosion (one), crush injury due to a falling tower crane (one). All the cases experienced closed spine injury except No. 2 who experienced open spine injury. All the injured vertebrae were located in the thoracolumbar segment and the Denis classification was burst fracture or fracture-dislocation.

All the six patients had thoracic and lumbar spine injury with paraplegia. The cases were prescribed prostheses and orthoses to stand and walk. The pressures of ischial tuberosity after wearing prostheses were all within the safe range (pressure <110mmHg). After rehabilitation training, all the six patients reached the walking level set for paraplegia patients without lower extremity amputation. Their self-care ability, bed-chair transfer ability and walking ability were significantly improved ( $p < 0.05$ ) (Table 2, 3).

**Table 3.** Changes in neurological function (ASIA) and ADL (FIM) (admission/discharge)

Case No	Sensory score	Motor score	AIS	FIM motor score*
1	76/76	50/50	A/A	33/55
2	82/82	50/50	A/A	25/59
3	93/94	50/50	A/A	32/53
4	84/86	50/50	A/A	20/47
5	84/84	50/50	A/A	30/56
6	98/100	50/50	A/A	15/43
Mean	86.17±7.96	50	A	25.83±5.83
	87.00±6.55	50	A	52.17±4.78

ASIA: American spinal injury association; AIS: ASIA impairment scale; FIM: functional independence measure

\* $p < 0.05$

## DISCUSSION

Spinal cord injury with amputation is usually caused by high energy trauma or compound energy trauma, and in recent years, their occurrence has been increasing with the industrialization and development of China. Because such patients usually experience high energy or compound energy trauma, multiple injuries are often seen, which leads to difficulty in diagnosis and treatment. Complications for these patients often include pressure ulcers, phantom limb pain, neuropathic pain, low back pain. Loss of motor and sensory function due to spinal cord injury and loss of body image after amputation will influence the rehabilitation process both physiologically and psychologically. For spinal cord injury patients without amputation, locomotor training is relatively easy and effective for motor recovery and walking ability<sup>1)</sup>. However, for the spinal cord injury cases with amputation, the rehabilitation and training is more challenging.

When discussing spinal cord injury with amputation, it is necessary to first make clear whether or not an upper limb or lower limb has been amputated. For example, a T10 complete spinal cord injury patient with unilateral lower extremity amputation can achieve good ADL after rehabilitation due to the intact upper limb function. However, when an upper limb is amputated, ADL will be adversely influenced. A prostheses is used to restore the original limb image integrity or to compensate for lost function, and a lower limb prostheses is specially designed to support the body weight and for walking<sup>2)</sup>.

Only a few studies were found in the literature in a search using both spinal cord injury and amputation as key words. Previous studies report that spinal cord injury combined with lower limb amputation is a contra-indication for wearing prostheses because of sensory dysfunction or absence. Ohry et al.<sup>3)</sup> reported spinal cord injury patients with different levels of lower limb amputation below the neurological level often result in back pain and stump pressure sores, emphasizing the sensory loss of the amputated limb is a contra-indication for functional or decorative prostheses.

Herman<sup>4)</sup> reported one case with thoracic spinal cord injury and thigh amputation successfully improved his ADL after using a prostheses to stand and walk. Shin<sup>5)</sup> reported another similar case with thoracic 12 spinal cord injury and one thigh amputation. However, no quantitative evaluation was performed in either study.

In recent years, the accumulation of experience in rehabilitation engineering and biomechanical knowledge has been applied in the field of artificial limb prostheses and orthoses, and the skin of paraplegic patients with lower extremity amputation can withstand a certain amount of pressure. In this study we used a Tekscan pressure testing system to test the ischial tuberosity pressure under condition of static standing and dynamic walking on flat ground with the assistance of walkers. The measurements of the six cases were less than 110 mmHg, which means it is safe for them to wear functional lower limb prostheses. In this study, prostheses and lower extremity orthoses were both used to improve the functional ability of the individuals, considering their dual disabilities caused by spinal cord injury and lower extremity amputation. Because of the severe damage to the spinal cord, neurological function of the cases was not significantly improved, despite sufficient effort in rehabilitation in exercises. However, ADL assessed by FIM subscales, improved significantly, which may be the result of adaptation and substitution after comprehensive rehabilitation with the assistance of prostheses and orthoses.

In conclusion, it is an innovation to prescribe prostheses for spinal cord injury patients with lower limb amputation with monitoring of ischial tuberosity pressure. With the development of science and technology, spinal cord injuries with lower limb amputation should no longer be a contra-indication for prostheses. Team approaches based on comprehensive rehabilitation evaluation and formulation of individualized rehabilitation plans is necessary to restore the body image, to improve the self-care ability, and to help patients return to home and to society.

## ACKNOWLEDGEMENT

Grant support for this study was provided by Capital Medical Development Fund of Beijing, China (No. 2014-4-4144).

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